MASTER’s THESIS – Integrated Water Resource Management

TH Köln (University of Applied Sciences)

ITT- Institute for Technology and Resources Management in the Tropics and Subtropics

COSTS OF WATER RISKS – CASE OF A PERUVIAN AGRICULTURAL COMPANY

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ABSTRACT

Water risk assessment is becoming an essential part of any decision-making process in the business sector. In the world where freshwater resources are becoming scarcer, water risks are growing and causing high costs to businesses. Therefore, numerous frameworks, guidelines, methodologies, tools, and other approaches were developed during the last century. Various scholars have appeared to give an economic value or price for environment goods in order to understand trade-offs better. Nowadays, the corporate world tends to use different approaches to convert sustainability management data to the financial language of decision-makers. This study explores the possible ways for a company to measure the costs of water related risks. It examines how to convert water risks to financial risks using a Peruvian agricultural company. The results show, that from all today's available frameworks, guidelines or tools there is no one commonly accepted and recognised as the best for water risk assessment and monetising. It was learned, that available tools could provide just a simple overview of possible water related risks and calculate their costs in a very general way. The work also highlights the importance of regular and appropriate data collection on the company level in order to be able to assess water risk related costs for the business.

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LIST OF ACRONYMS

µS	Micro siemens
CEO	Chief Executive Office
cm	Centimetres
ENSO	Southern Oscillation
ESG	Environmental Social Governance
EUR	Euro
ha	Hectares
ILO	International Labour Organization
kg	Kilogram
km	Kilometre
KPI	Key Performance Indicators
L	Litre
LCA	Life Circle Assessment
masl	Meters above sea level
mb	body-wave magnitude
MCM	Million Cubic Meter
mg	Milligram
MW	Megawatt
OHS	Occupational Health and Safety
PEN	Peruvian soles
S	Second
USD	U.S. dollar
WF	Water Footprint
WRF	Water Risk Filter
WRM	Water Risk Monetizer
WWTP	Wastewater Treatment Plant

1. INTRODUCTION

Scientists are aware about present and future water challenges on our planet and therefore pointing out the need for urgent response and actions. Businesses and organizations have been the ones who from time to time highlighting those challenges directly in their financial statements. KPMG warned companies in all sectors “to prepare themselves for a world where raw materials may be in short supply and subject to price volatility including large price increases and increased disruption to supplies” (KPMG 2012). World Economic Forum named water risks “the biggest threat facing the planet over the next decade” (WEF 2015, 2019). Other authors argue that most of water risks for companies is likely to be beyond their operations and direct control, which highlights the importance of corporate programs focused on managing supplier-related water risks (Makower 2018).

Risk assessment is an essential part of any decision-making process. The situation becomes more critical if it has an influence on the business future and could have a very high cost. Water risk is one of the risks with the highest impact on a company. According to the World Economic Forum report in 2019: extreme weather events (e.g., floods, storms, droughts) and water crises are on the third and fourth places respectively in the risks by impact rating (WEF 2019). Therefore, numerous of frameworks, guidelines, methodologies, tools and other approaches were developed during the last century. Various scholars have appeared to give an economic value or price for environment goods in order to better understand trade-offs. Natural capital accounting (Laurin 2017; Missemer 2018), ecosystem services evaluation (Aznar-Sánchez et al. 2019; Zhou et al. 2019), business impact on environment, water footprint (Hoekstra 2011), water life cycle assessment (Pfister et al. 2017; Laurin 2017) are already long standing concepts for evaluating water importance and impact on it. However, most of the efforts were in understanding of water valuation (i.e., putting monetary or non-monetary value), and just few were looking parallelly into the water risk assessment for business (Morgan et al. 2018). Still, corporate´s and investor´s concerns related to water risks arise more frequently every year and is likely to continue rising significantly due to poor water management and valuation practices.

Therefore, businesses are in need to identify and assess water related risks as well as a suitable methodology to do so. Thus, this study is aimed to investigate the possible ways for a company to measure the costs of water related risks through providing answers to the following research questions:

- How could the term “water risk” be defined?
- Which water risk evaluation frameworks or guidelines are available for corporate world?
- Which tools are available for the monetary assessment of water related risks for businesses?

The most suitable frameworks, guidelines and tools will be applied for the studied company. As a case study for this thesis, an agricultural company in Peru was chosen. For the agricultural sector the water risks are one of the highest. This business sector is responsible for more than 70% of freshwater consumption worldwide (World Bank 2019, 2019). Using the Peruvian agricultural company input, this study will evaluate additionally these research questions:

- To which degree could the selected water risk assessment and valuation tools be used for costs analysis?
- Which model could be suggested for the calculation of the costs of water risks?

Regarding the structure of this thesis, Chapter 2 will identify the term “water risk”; review and assess available frameworks, guidelines and tools for water related risks. Chapter 3 will determine and analyse water related risks for the case study company via publicly available data and Company´s interviews. As next step, Company´s water related risks and its costs will be evaluated using the chosen tools in Chapter 4. Finally, within available data from the business, Chapter 5 will propose a possible model for water risks cost calculation.

2. WATER RISK DEFINITION AND ASSESSMENT

In this chapter water risks will be defined for this study. For this purpose, scientific and corporate literature are reviewed in order to choose the most suitable definition. As a next step, water valuation methods are briefly revised to select the most fitting for water related risks valuation. Finally, water risk valuation and assessment tools, frameworks and guidelines are reviewed and analysed.

2.1. Scientific literature definition

The literature proposed several methods to evaluate water related questions in companies (e.g., sustainable usage, reducing technics and efficient management). There are three highlighted methods to link water usage and business sustainability: to quantify actual water usage via Water Footprint, to analyse water circle and impact via Life Circle Approach and to include water as important item in corporate decision-making process via water stewardship. But none of them define water risks or their potential financial impact on a company. The term “water risk” still does not have one precise definition in the scientific literature. Frequently authors are using it in parallel with other terms like water scarcity, water stress or hazards. Available methodologies are more concentrated on water usage in the business.

The Water Footprint is a volumetric approach, focusing on water productivity: “The water footprint of an individual, community or business is defined as the total volume of freshwater used to produce the goods and services consumed by the individual or community or produced by the business” (Chapagain 2017; Hoekstra 2011). Followers of this methodology argue that it is a useful tool for addressing the imbalance between the supply and demand for various water flow (Novoa et al. 2019; Spiess 2014).

The Life Circle Assessment is an impact-oriented approach. It translates water consumption in different regions into potential need of other consumers and local ecosystems over the entire life cycle of a product or service. The main aim is to minimise global potential impact on human health and ecosystem quality (Boulay and Lathuillière; Dominguez et al. 2018).

The two aforementioned methods are broadly similar and cover both the calculation of water use and its impacts but differ in addressing a water footprint result. Nevertheless, followers of both theories have longstanding fight about the terminology and methodologies (Hoekstra 2016; Pfister et al. 2017; Schaefer et al. 2019). Moreover, both approaches are not differentiating water risks and its consequences for a company, they are more concentrating on water usage and water balance. They provide a foundation for subsequent examination of water-related risks associated with company’s operations and supply chains.

However, literature has large amount of various water risk indicators and possible ways to calculate them. For instance, some authors used an adapted Monte Carlo Analytic

Hierarchy Process (MCAHP) to construct a single index, started from 6 public available measurements (Schaefer et al. 2019). Water Resource Institute developed the Aqueduct Water Risk, in which they introduced 12 different water risks indicators (Reig et al. 2013). These examples include some water risks, but there is some weakness in all approaches and authors are publicly mentioning them.

2.2. International institutions and organisations definition

The corporate world adopted the Water Footprint and the Life Circle Assessment technics, and used them to define company's water demand, wastewater produce across the operations and supply chain. That assessment helps to highlight the geographic locations where the water dependency is higher and to understand the nature and magnitude of company's influence on water (Everard 2019; Kreutzwiser et al. 2011). As water question becomes urgent for companies, water stewardship approach was introduced. Water stewardship is "the use of water that is socially equitable, environmentally sustainable, and economically beneficial, achieved through a stakeholder-inclusive process that involves site- and catchment-based actions" (AWS 2019). This approach aimed to help a company understands own water usage, catchment context and shared risk in terms of water governance, water balance, water quality and important water-related areas; then engage in meaningful individual and collective actions that benefit people and nature (ewp 2019). Water stewardship is a key practice for companies to identify water risks and drive sustainable water management. From "water risks" definition's point of view, this method put more attention to define water risks then the Water Footprint and the Life Circle Assessment, but the definition was developed with international NGOs and corporate world collaboration.

With emerging corporate water assessment tools and stewardships approaches and methodologies, the variety of "water risks" definitions and other water-related terms rise as well. Moreover, they started to overlap each other and sometimes lead to conflicting interpretations. In 2014, representatives from the CEO Water Mandate, Alliance for Water Stewardship, CDP, Ceres, The Nature Conservancy, Pacific Institute, Water Footprint Network, World Resources Institute, and WWF together produced a report, in which they agreed on the terminology (The CEO Water Mandate 2014b). According to that document, "water risk refers to the probability of an entity experiencing a deleterious water-related event". The illustration below shows how water related terms are connected (Figure 1).

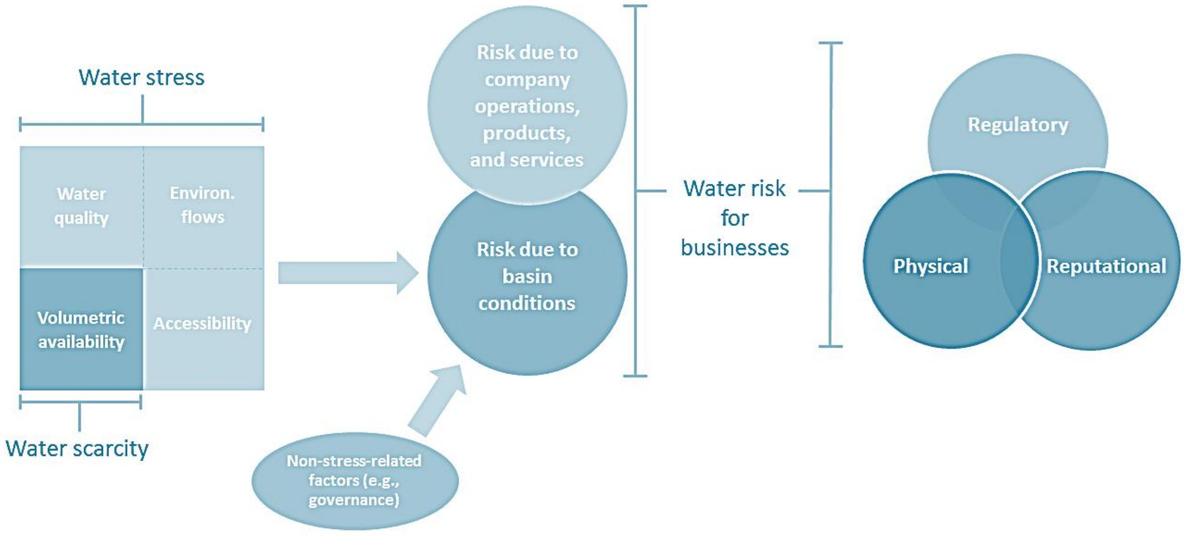

Figure 1. Relationships between terms "water risk", "water scarcity" and "water stress" (The CEO Water Mandate 2014b).

Furthermore, it was admitted that water risks can be felt variously for different sectors, even when they are impacted by the same degree of water scarcity or water stress. A company can experience diverse water related risks depending on the nature of its operations, such as water dependency, product portfolio, supply chain, location environment (physical and political).

2.3. Water risks for businesses

To be more specific and to understand better water challenges, different categorisations were introduced. On the one hand, water risks for businesses could be differentiated due to the source of the risk (The CEO Water Mandate 2014b):

- Risk due to company operations, products, and services: *A measure of the severity and likelihood of water challenges derived from the way in which a company or organisation, and the suppliers from which it sources goods, operate and how its products and services affect communities and ecosystems*.
- Risk due to basin conditions: *A measure of the severity and likelihood of water challenges derived from the watershed context in which a company or organisation operates, which cannot be addressed through changes in its operations and requires engagement outside the fence.*

On the other hand, to understand and classify water risks categorisation in three sectors could be used (The CEO Water Mandate 2014b; WWF 2011; Reig et al. 2013; Morrison et al. 2010):

- Physical risks *stem from having too little water (scarcity); too much water (flooding); water that is unfit for use (pollution), inaccessible water. They can be caused by drought or long-term water scarcity, over-allocation among users, flooding, or pollution that renders water unfit for use*.
- Regulatory risks *occur because of changing, ineffective, poorly implemented, or inconsistent water policies. Stricter regulatory requirements often result from water scarcity, ensuing conflict among various users, or excessive pollution. Ineffective policy can create a less inviting or stable business environment or degraded catchment conditions because of incoherent policy design or inconsistent application and enforcement*.
- Reputational risks *stem from changes in how stakeholders view companies' real or perceived negative impacts on the quantity and quality of water resources, the health and wellbeing of workers, aquatic ecosystems, and communities. Reputational concerns lead to decreased brand value or consumer loyalty or changes in regulatory posture and can ultimately threaten a company's legal and social license to operate.*

2.4. Water valuation approaches

The value of water could be given in monetary and non-monetary (e.g., spiritual) ways. Business perspectives on valuation use to be expressed in monetary way, that is why this study will just review this part of valuation. Ultimately, the water value ranges depend on the actor, context and scale. ´Water price´, ´water cost´ and ´water value´ are most used terminologies for evaluation but could be misinterpreted. The "the Value of Water" report from WWF and IFC distinguish these terms for the corporate as next (Morgan and Orr 2015):

- Water price is a charge typically put by government regulations via water service providers. The price is known and expected by business or other user, here is also future prices are included.
- Water cost is a total cost connected with water withdrawal, discharge and operation as well as other costs (filtrating, treatment, energy to heat/cool, administrative and other investment in water related infrastructure). Water cost has a direct link with the water price.
- Water value is more comprehensive view, which includes a company economic, social and natural value.

Governments, policy makers, water agencies, academia, water service providers (incl. irrigation service) and another public sector bodies could have various intentions behind the water valuating process. Some might aim to decrease/increase water consumption, recover costs, relocate water withdrawal, decrease pollution or improve water quality. As practise shows, the water prices (i.e., tariffs) are largely not correlated with physical water risks and barely covering maintenance and operating purposes (Rogers 2002; Circle of Blue 2019; Liu et al. 2009). Direct opposite situation could be observed, when the places with abundant water resources have the highest water prices (e.g., Denmark) and the water scares regions have the lowest prices (GWLG 2018). The reason for such low prices has plenty of explanations: water is basic human right and "should be free"; to secure food production; to stimulate economic growth (i.e., subsidise water tariffs for industries and agriculture); political interference (Morgan et al. 2018). Appropriately such poor practice will not lead to the national or regional economic development. Especially for agricultural sector, irrigations pricing scheme should be rethought in order to secure water location and food production (Ziolkowska 2015). As agriculture is using more than 70% of global freshwater consumption (World Bank 2019), it is vital to ensure that it is managed wisely. It is difficult to differentiate approaches which are used only by public sector actors from those which are used by private actors. In present time with rising competitions for resources (especially for fresh water), both sides are implementing all available methods.

Thus, many economists made researches on linking economic value to water. As a next step, with a help from environmental organisations, they took those researches as a base for common used frameworks: The Economics of Ecosystems and Biodiversity (TEEB 2013), System of Environmental and Economic Accounts (UN 1993), Millennium Ecosystem Assessment (MA 2005), Common International Classification of Ecosystem Services (Haines-Young and Potschin 2017); Mapping and Assessment of Ecosystems and their Services (Maes et al. 2018) and many other. For instance, the Paying for Ecosystem Services approach (i.e., watershed services) is widely used by policymakers and governments around the world to establish a value exchange mechanism between all beneficiaries and provisioners (Bullock and Ding 2018). The Economics of Ecosystems and Biodiversity is an initiative hosted by United Nations Environment Programme, created in 2013. It is providing a methodology of monetary and non-monetary valuating of ecosystem services and biodiversity (TEEB 2013). Since 2014 it became the Natural Capital Coalition. Within this approach, special guidelines were developed for agricultural sector, taking in account all business particular operations (TEEB 2018a, 2018b).

A brief history of Natural Accounting framework development is described in 2017 report from the European Commission (Science for Environment Policy 2017). The report also shows interconnections between different scholars' streams, critics and possible improvements of each approach. The far-reaching overview of economic methods is presented in "Determining the Economic Value of Water: Concepts and Methods" work (Young and Loomis 2014), which includes numerous of inductive and deductive approaches and how they could be applied (Table 1).

Table 1. Main types of Economic valuation methods (Young and Loomis 2014)

Valuation method	Brief description
Inductive methods	
Observation of water market transactions	Observed prices of long- or short-term water rights
Econometric estimation of production and cost function	Statistical analyse of primary or secondary data of business inputs and outputs
Econometric estimation of municipal water demand functions	Statistical analyse of primary or secondary data of municipal water use

Travel cost method	Analyse of variation in visitor travel costs in addition to econometric approach to measure the demand for recreation on the study area.
Hedonic property value method	Econometric analyse of real property purchase with different variants of water supply and quality
Defensive behaviour method	Reduction of bills for people, who mitigate or avoid externalities (as water pollution). Measure the benefits of supportive policies
Damage cost method	Maximum willingness to pay given as a monetary value of avoided damage
Contingent valuation method	Study return from possible changes in environmental goods or services in monetary valuation
Choice modelling	Statistical analyse of the people´s preferences among different policies
Benefit transfer	Study benefits of one site and use them as a measurement base for another site
Benefit function transfer/meta-analysis	Using available information or previous study of the same topic to make a generalisation of the subject
Deductive methods	
Basic residual method	Using spreadsheet or budget analyse to link water to net income
Change in net rents	Using spreadsheet or budget analyse to link water to rent
Mathematical programming	Using fixed price optimisation model to link water to net income, rent or marginal costs
Value-added	Linking water to direct or indirect business rent via value-added measure from input-output
Computable general equilibrium models	Linking water to direct or indirect business rent via price-internal optimisation model
Alternative cost	Value assigned to costs savings from the next best alternative source of service

2.5. Frameworks, guidelines and tools review

In this section, the analyse of available approaches and tools for water risk assessment will be presented. The corporate world tends to use numerous approaches to convert sustainability management data to the financial language of CEO and other decision makers. To measure their environmental matters, businesses often are coming to topics like: business environmental impact, biodiversity, natural capital accounting, ecosystem services measuring, resource efficiency, business sustainability and true costs of resources. These are some of the most common used headlines in the companies´ reports, where the topic of water risks could be mentioned.

2.5.1. Business disclosure tendency

The corporate world and investors are very engrossed in valuating water resources, but their interest is more shifted to assess water related risks and opportunities for the business.

Multibillion-euro infrastructure and equipment costs for water desalination/treatment, multimillion-euro fines for breaking water regulations or polluting, even reaching to business shut-down because of local community concerns around its water management are just some of the water risk impacts what business could face (WWF 2011; Chapagain 2017; Ceres 2019). Therefore, businesses and investors from all over the world have recognised the growing impact of water related risks, and companies started to disclosure their water impact. Intuitively, some companies are presenting their sustainability reports (i.e., environmental and social reports) yearly or even more often, others are making their impacts and management strategies public via initiatives as CDP[1] and GRI[2] or others. For instance, in 2018 alone 2,114 companies together reported USD 38.5 billion of water related financial losses (CDP 2018). Till today there is no one standard and internationally recognised approach how to measure water risk impacts, each company is doing it in a different way.

According to the WBCSD report, Asia-Pacific and Europe are doubling their reporting requirements every decade. In the same time South America is showing stable grow in the period of 1990 – 2010, and North America has tripled reporting obligations since 2010 (WBCSD 2018). 72% of all reporting requirements are mandatory and the rest is voluntary for companies. The mandatory reports are part of specialistic system for specific agencies or regulatory bodies. The voluntary ones are disclosure through open mainstream organizations. The second option allows companies to share the information between broader circle of stakeholders. Nevertheless, the same report states that just 19% (from 1,790 sustainability reporting provisions) specify water matters in their reports, the rest disclosure water topics in a mix with climate change, human rights and other ESGs.

With time, initiatives became more comprehensive, but still all have their strengths and weaknesses. Meanwhile, international organisations looking for standardisation of ways to monetarise business impact on environment (incl. water resources). In 2017 Financial Stability Board announced standards for the Task Force on Climate-related Financial Disclosures[3] which were developed for voluntary climate-related financial disclosure and now implemented in the majority of disclosure initiatives (incl. CDP). More recently, in March of 2019, the International Organisation for Standardisation developed ISO 14008:2019 "Monetary valuation of environmental impacts and related environmental aspects" with a goal to bring more transparency and common terminology in the topic, but this standard does not determine how to put or use monetary value on company´s operation (ISO 2019a). The last will be the task of the ISO/FDIS 14007 "Environmental management – Guidelines for determining environmental costs and benefits", which is planned to be published in October 2019 (ISO 2019b). Consequently, international community is moving in the direction of reporting standardisation of non-financial matters. But still a lot of work and research should be done to find the best solution of accounting water value for the business and its impact on it.

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[1] https://www.cdp.net/en/water
[2] https://www.globalreporting.org
[3] https://www.fsb-tcfd.org

2.5.2. Frameworks and guidelines

Most of the guidelines and frameworks for monetary valuation of water related risks were developed in a line with aforementioned topics (e.g., biodiversity, natural capital accounting, ecosystem services). The intention behind is to create a suitable way of communicating business activities and impact regarding sustainability topics to the investors or other shareholders. In addition, frameworks help to monitor company´s operations and supply chain, to check environmental targets achievements. Monetary valuation serves as a common unit in comparisons and trade-offs between different environmental issues.

During this study several frameworks, guidelines and reporting initiatives were reviewed. The complete list with the most relevant ones for purpose of this study could be find in the Annex 7.1 (Table 10). These are providing broad set of methods on how monetary value could be put on environment, including water resources. Barely number of them specialised on water matters (Table 2), the rest trying to overcome the whole scope of environmental and social risks. Just some of mentioned approaches differentiating between physical, regulatory and reputational water related risks. A few of guidelines are explicitly for one business sector (e.g., beverage, water utility services). The overall tendency is that all were developed during last 15 years. What shows that civil and business interest in environmental subject is rising as resources become scarcer. Most of approaches are free accessible on the internet and could be used for the purposes of business. Some have engagement hubs with large number of followers. During the study, it was noticed that many of businesses rely not only on one guideline or framework, but on several at the time. In turn, authors are also referring to each other´s work during a framework´s development.

Table 2. Water specifically frameworks and guidelines for valuation and risk assessment.

Name	Form			
	Engagement Hub	Methodology / Guidance	Framework	Report
2030 Water Resource Group	X			X
AquaWatch	X			
CDP Water	X	X		X
IUCN's Water Programme	X	X		X
OECD Water			X	
RECon		X	X	X
Value of Water Framework			X	X
Volumetric Water Benefit Accounting		X		
Water Action Hub	X			
Water Funds Toolbox	X		X	
Water Risk Valuation Model				
White Paper: Valuing Water to Drive More Effective Decisions		X		

Frequently, the same organisation or business could be the member of several initiatives, so in the end all of them are connected and aware of each other. But still, there is no agreement on one commonly used guideline or framework for all business players. It could be partly explained by prevalent overall generalisation in all frameworks and methodologies. Regarding the water risk assessment and monetarising, each of the reviewed scheme is just suggesting to highlight, measure and valuate risks. But the way how it should be done is up to a company. In the best scenario, reference to some economical valuation approaches could be mentioned.

The conclusion of this review is, from all today's available frameworks or guidelines there is no one commonly acceptable and recognised as the best for water risk assessment and monetarising. Some of them are more comprehensive and well known than others, but still there is a room for improvement. It is hard and sophisticating process to find a universal solution for each business sector in each location. The Institute for Sustainability Leadership of Cambridge University in 2017 published a study with assessment of main organisations involved in measurement and decision making support (Di Conzo and Himme 2017). The key finding of this work also states that business world is still missing one universal method for measuring its environmental impact and related risks.

2.5.3. Tools review

Many companies and organisations made several steps towards actual creation of one tool for water risks assessment. However, the tools reviewed during this study shows that most of them were just in field of putting value on water, measuring ecosystem services or biodiversity, assessing business´ impact on environment. However, the aim of this review was to find a model which helps investors or companies to understand business´s potential water risks via monetary cost and shows weaknesses in water management strategy.

As a result, several tools were reviewed, the list of the most relevant for this work could be find in the Annex 7.2 (Table 11). The overall status on the tool's market is similar to the frameworks and guidelines. These tools could be distinguished in the same topic range as guidelines (e.g., biodiversity, natural capital accounting, ecosystem services). Few of them are water specific (Table 3). Moreover, they could be differentiated as databases (e.g., set of maps), software or calculators (e.g., excel or web based). Regarding the audience, it might be developed specifically for business sector, requiring specific operational information or for public sector, using just commonly accessible information. In addition, some of them are created with a special purpose (e.g., for farms, green infrastructure, beverage industry). There are tools which developed specially for one or few countries (e.g., India Water Tool, Natural Capital Planning Tool, WaterMAPP). Most tools are free accessible, but some require special membership or paid subscription in order to obtain comprehensive results on study. Nevertheless, the paid ones have free access to some case studies where they were applied, so they could be used as an example of possible results from this tool.

Table 3. Water specific valuating / risk assessment tools.

Name	Calculator	Database	Excel	Software
Aqueduct Water Risk Atlas		X		X
Aqua Gauge			X	
Growing Blue tool		X		
GWI Water Data		X		
India Water Tool		X		
Water Scarcity Atlas		X		

WaterWorld		X		
World Water Atlas		X		
Corporate Bonds Water Credit Risk Tool	X		X	
Drought Stress Testing Tool	X		X	
Equarius Risk Analytics	X			
Global Water Tool™	X	X		
Green Infrastructure Support Tool	X			
Local Water Tool	X			
Save Water Campaign	X			
True Cost of Water	X			
True Cost of Water Toolkit (BIER)	X		X	
Water Calculation Tool for the Textile Wet Processing Sector	X			
Water Impact Index	X			
Water Risk Filter	X	X		
Water Risk Monetizer Tool	X			
Water Risk Valuation Tool	X			X
WaterMAPP	X			

Some of the most used methodologies, which are behind those tools, are mentioned below (Table 4). As a common practice some tools are integrating two or more methods together to reach more accurate results. In addition, with almost every few years, some tools are getting more improvements and releasing new versions whereas others are not being supported anymore and terminate the project.

Table 4. Water valuation approaches and examples of tools (Morgan et al. 2018)

Name	Description	Examples	Source
Shadow pricing	The allocation of monetary value to an abstract commodity (e.g., water, carbon emission), which has not regular price via index of special circumstances (e.g., water stress). This provides a systematic approach to integrating water risk into financial analysis	Bloomberg LP Water Risk Valuation Tool (WRVT)	(Bloomberg LP 2015)
		Corporate Bonds Water Credit Risk Tool	(Ridley and Boland 2015)
		Water Risk Monetizer	(ECOLAB 2017)
Value at Risk	The statistical method used to measure and quantify the level of financial risk within a company or investment portfolio over a specific time frame[4].	Equarius Risk Analytics	Equarius[5]
Probabilistic value adjustment	The assignment of a risk-weighted monetarize value modification to aspects of financial statements. Modelling the best, the worst and most likely scenario.	Water Risk Filter (WAVE)	(WRF 2019)
		True Cost of Water tool	Veolia[6]
Financial impact disclosure	The actual (past) financial value impacted and driven by water-related factors as disclosed by companies to investors - typically via specialised disclosure initiatives or footnotes in annual financial reports.	Global Reporting Initiative	(GRI 2015)
		Corporate Water Disclosure Guidelines	(The CEO Water Mandate 2014a)
		CDP water programme	(CDP 2018)

[4] https://www.investopedia.com/terms/v/var.asp
[5] https://www.equariusrisk.com/
[6] https://www.veolia.com/en/citizens/innovation/true-cost-water

Integrated Profit and Loss (Environmental Profit & Loss (EP&L))	Developing a coefficient to convert the primary data from a company into impact on human well-being and environment. Taking in consideration different impact in rural and urban places as well as wet and dry countries etc.	Puma, Kering´s EP&L	(CISL 2016; Kering 2017)
The Total Economic Value	The framework for looking at the practical value of ecosystem. Typically distinguishes between use value and non-use value.	Corporate Bonds Water Credit Risk Tool	(Ridley and Boland 2015)
		Green Infrastructure Valuation Toolkit (GI-Val)	(GIVaN 2011)
Payment for Ecosystem services / Watershed Services	A voluntary transaction between a service buyer and service seller that takes place on the condition that either a specific ecosystem service is provided, or land is used in a way to secure that service	Integrated Valuation of Environmental Services and Tradeoffs (InVEST)	(Wunder 2005, IUCN 2009)

In respect for input, the user in most cases does not need to have an advance knowledge in hydrology, programming (e.g., The Madingley Model) or any other discipline. However, some tools require deep data pre-collection (e.g., Ecosystem Services Identification & Inventory, Soil & Water Assessment Tool). Concerning possible output what could be obtained after application of reviewed tools, it could be classified in four types: qualitative, quantitative, socio-economic and financial. The difference between socio-economic and financial, in this study, that both forms might be expressed in monetary form (Morgan et al. 2018). But socio-economic value might be understood as calculation of social perceptions, cultural values and other trade-offs (e.g., determining externalities, informing allocations).

Several organisations were identified who presented toolkits (i.e., list of various tools and guidelines; e.g., Natural Capital Protocol Toolkit, Ceres´ Investor Water Toolkit) or step by step instruction how to choose a tool (e.g., Water Funds Toolbox). But not all revised tools allow to monetarise water relevant risks for business, even though they tend to do so in the description of the tool. Most of them could be used just as a guideline, a first step, to determinate business´ water management weaknesses. Nevertheless, the obtained results tend to be a general overview with low level of specialisation for an enterprise. Another option could be using consultancy services (e.g., 427mt, Equarius Risk Analytics). The results might be more detailed but also more expensive.

So, as a conclusion, the business has to use few tools together in order to obtain comprehensive results. As an example, a company could start with tool for identifying physical water risks (e.g., Aqueduct Water Risk Atlas), then determine reputational and regulatory risks (e.g., Water Risk Filter) and move to the economic value of water risks (e.g., Water Risk Monetizer, InVEST). This method will be used during this work. In the scope of this study, detailed and specific analyse of water related risks (incl. physical, reputational and regulatory risks) will be assessed. Firstly, publicly available data and insides from interviews will be studied (see Chapter 3). As a next step, the case study company will be screened through chosen water risks tools (see Chapter 4).

3. CASE STUDY DESCRIPTION

In this study it will be examined how to convert water risks to financial risks using a Peruvian agricultural company (the Company) as a case study. In order to maintain confidentiality, the study does not use the real name of the enterprise and all financial data are based on assumptions and have been modified and anonymized. All the information about the Company is provided by personal interviews and public accessible information. The timeline of this work is 28 years, from 1990 till 2018.

3.1. The Company

The Company today (2019) belongs to the category of large farms and is oriented for export. It runs several processing plants and owns around 2,000 ha of fields in the study area plus rents around 1,500 ha. It obtained several international certifications, which allows the Company to be a global food producer and supply with its products markets in the United States of America, Europe (mainly Australia, Spain, Germany, Netherlands) and China.

Since 2007, the Company obtained financing and technical support from different international financial institutions. This cooperation is also helping the Company to structure its efforts to achieve sustainable development and production. In particular interest of this study are topics as water efficiency, water use and effluents reduction. The Company showed significant improvements in environmental and social matters. Some detailed examples are described in relevant sections below. The positive change was due to the establishment of the Integrated Environment Management System (GIS - Sistemas Integrados de Gestión) with plans such as: Environmental Conservation, Corporate Social Responsibility, Archaeological Survey & Protection, Water Resource Management, Operation Health & Safety, Emergency & Contingency, and Integrated Pest Management.

3.1.1. Location

Company's fields are located in the northern coastal part of Peru, in La Libertad department. This is around 550 km from Lima, the capital of Peru. Its metropolis and most populated city is Trujillo, with a population 970,016 citizens, around 548 inhabitants/km² (INEI 2017). In addition, it is the third biggest and most densely populated province in Peru, after Lima and Piura.

This location has advantages of suitable climate conditions for agricultural activities making it good for global market since the weather in the area allows to get up to 3 yields during one year for some crops like asparagus. For others it provides possibility to take advantage of "harvesting window", so the Company can have yield when in some places the season already finished and for other locations still has not started. Moreover, the most important factor for agricultural activities is sufficient irrigation infrastructure in the place, which makes the area attractive for agrobusiness investments. Therefore, in the catchment study area, the Company shares these advantages with another 9 big agrobusinesses with 2,000 ha of each in average and with a number of medium and small farmers.

Regarding the transportation infrastructure, local producers rely mainly on roads transportation to the port of Lima (about 550 km) and from there to other parts of the world. It is the cheapest way but has the highest risks of interruption during the floods season. For instance, in 2017 some roads were under water, bridges were broken, this was interrupting transportation for around 10 days. Alternatively, in the study area there is the Salaverry Port Terminal, which is operated by government, and currently cannot run on his full capacity as it requires maintenance, rehabilitation and modernization. The distance from the Salaverry Port Terminal to the Callao Port Terminal (located in Lima) by sea is 410 km, about 140 km less then via road. This could be an alternative choice, but up to now the port does not have the needed capacity. There is the Carlos Martínez de Pinillos airport, which is of national / regional importance, but does not have any international connections. The airport is run by a private company, and is also in need of modernisation (CENEPRED 2018).

3.1.2. Crop portfolio and other products

The Company started business just with asparagus plantations, but after few years the diversification began. Today, the Company plants avocados, asparagus, artichokes and peppers, exports fresh and frozen products as well as ready to eat meals. The fresh products have higher margin, because the Company does not have additional operating / processing costs and nowadays the international market shows a growing demand for fresh crops. On the other side, canned products have longer expiration period and allow the Company to use all the crops, even what were partly damaged or didn't meet market standards for fresh products.

The diversification is also important because of the crop's lifetime. In case of asparagus, it can have a yield up to 10 years but the productivity will fall after the 5th year. Avocado trees, for instance, can be productive for 20 years and already after their 3rd year productivity rises up to 30%. It is important for the farmers not to push the crop for maximum yield on the first years, so the root system can get mature and be productive longer.

Furthermore, the Company procures nearly 40% of its fresh products (e.g., artichoke, asparagus and peppers) from about 275 small independent producers, about 15,000 tonnes per year. In addition, these producers are supervised periodically by Company´s technicians for the production quality.

3.2. Physical conditions in the region

As mentioned before, the Company fields are located in the Department of La Libertad. La Libertad is the only Peruvian region that includes all three natural regions of the country: coast, Sierra (highlands), and Selva (rainforest). Company´s fields are located just in the coastal part of the department, in the Virú and Moche rivers´ lower basins, which are the study region of this work (Figure 2).

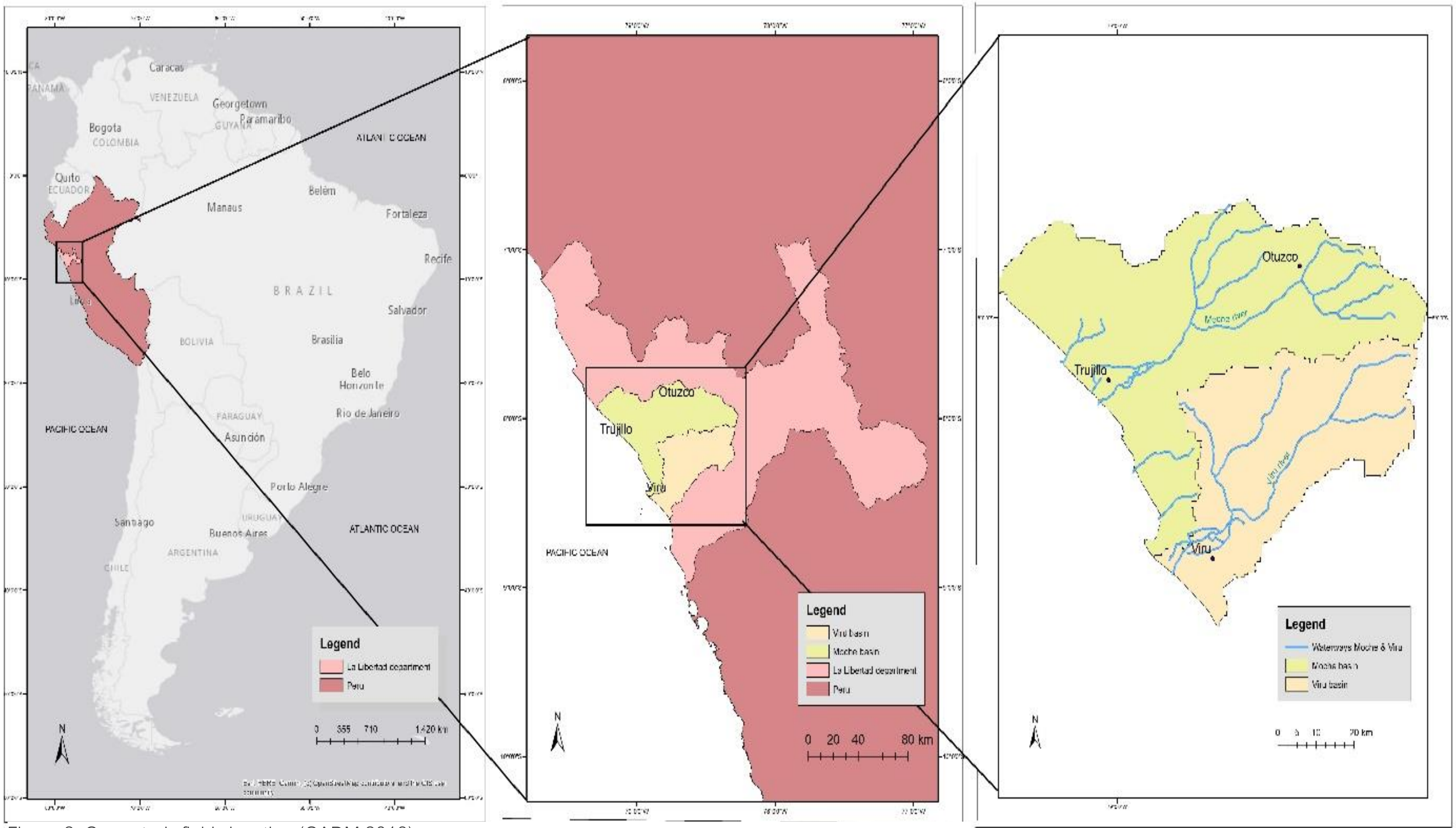


Figure 2. Case study fields location (GADM 2018)

The topography of study area contains variations in elevation, with a maximum elevation 4,300 meters above sea level (Figure 3). However, fields are just in the area which is up to 300 meters next on the coast. Therefore, in this work, the focus will be on the coastal part, but for comprehensive understanding of the physical conditions it is important to consider whole river basins´ catchment.

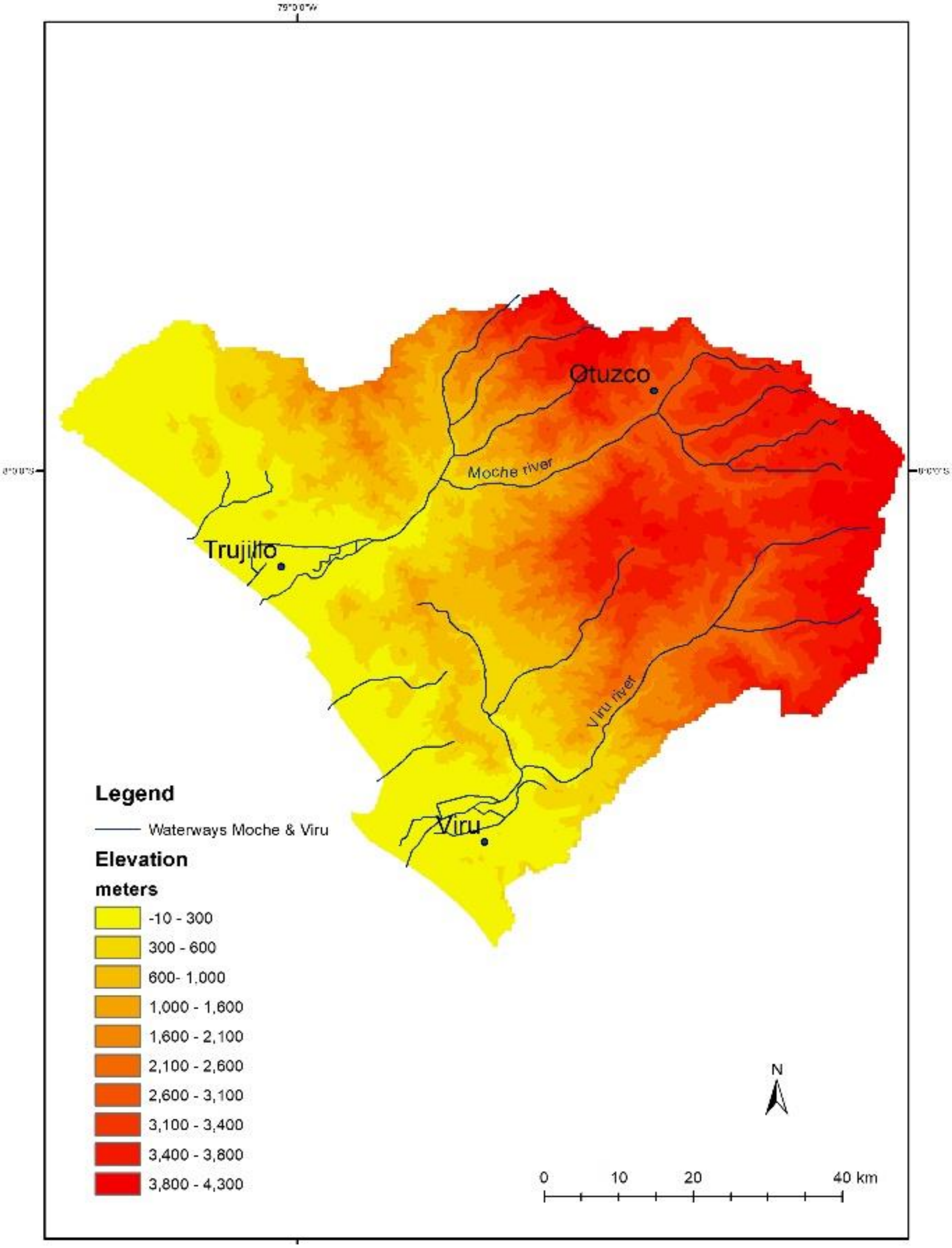


Figure 3: Elevation in the study area (SRTM 2018)

The land cover of the area is represented by shrubs, cropland, trees, grassland and bare area (Figure 4). In the study area, eutric regosols prevails as a soil type (FAO 2014). Because of that soil type, the irrigation in that region should be done more or less every day. The soil present there, can hold water just for 1 day during the summertime and for 2-3 days in winter. So, fields need water constantly.

The catchment has some seismic activities risks, archives from 1963 – 1980 have records of 6.6 mb, a critical earthquake has a return period of 60 years (ONERN 1973).

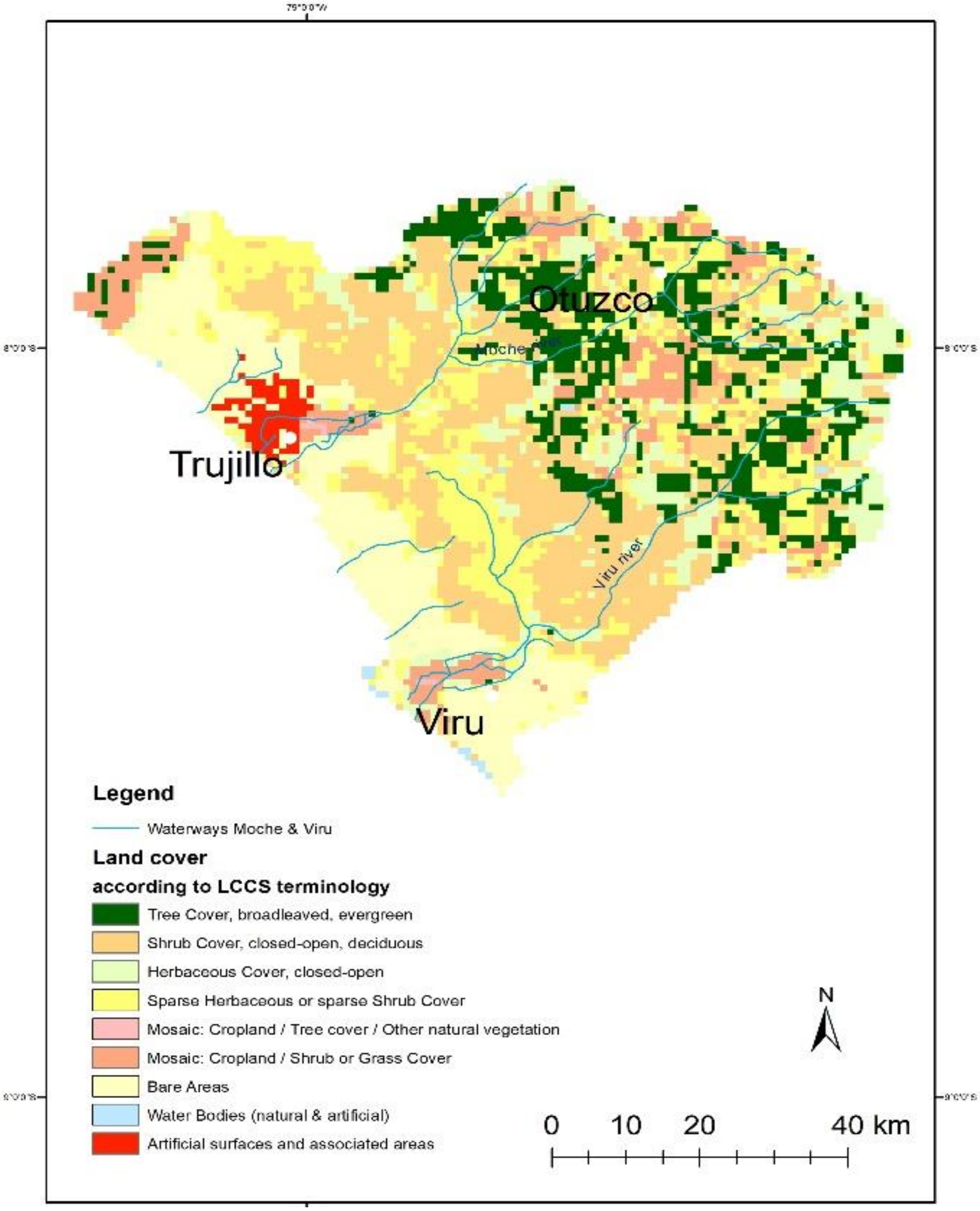


Figure 4: Land cover of study area (GVM Unit 2000)

3.2.1. Climate and weather conditions

The climate and weather conditions vary between the lower and upper elevations. The lower region, where the fields are located, has a desert climate. It is classified as BWh (B - main climate: arid; W - precipitation: desert; h - temperature: hot) by Köppen and Geiger climate classification (Kottek et al. 2006).

The metrological data for the study area has been taken from different stations located especially within the Moche and Virú basins. The stations are administrated by National Meteorology and Hydrology Service of Peru (SENAMHI).

The average annual temperature varies from 20 °C in the coast to 6 °C in the highlands. The area of the coast has an extreme maximum monthly temperature reaching an average of 28 °C, and extreme minimum monthly temperatures are around 14 °C. The summer period is January – April, with an average daily high temperature above 25 °C, the winter season is July – November, with below 22 °C (Figure 5).

The annual rainfall in the Moche and Virú river basins also differs among the whole area. If the highlands and places where all springs are, having an annual average of 1,200 mm, the coast has an average of 15 mm (Figure 6). Regarding the variation in time within the hydrological cycle, it should be noted that there is an inter-monthly rainfall variation, with the highest rainfall (80%) occurring during the period between December and March.

Humidity in the study area is in the range of 83-88% during the year. The evaporation in the catchment rises, as the elevation level decreases. Evaporation values in the lower zone of the basin reach 2,500 mm/year, in the middle zone – from 2,350 to 2,500 mm/year and in the upper zone the annual average is from 1,100 to 1,350 mm/year (Acker and Leptoukh 2007). The highest values of evaporation are in the period December - April in the coast and July - October in the mountains. The average annual evapotranspiration in the area is low, and varies as 6-7 (*10^{-6} kg m^{-2} s^{-1}) during 1990 - 2010 period, 9-8 (*10^{-6} kg m^{-2} s^{-1}) in 2011 - 2015, and 3-4 (*10^{-6} kg m^{-2} s^{-1}) in 2016 – 2018 (Acker and Leptoukh 2007).

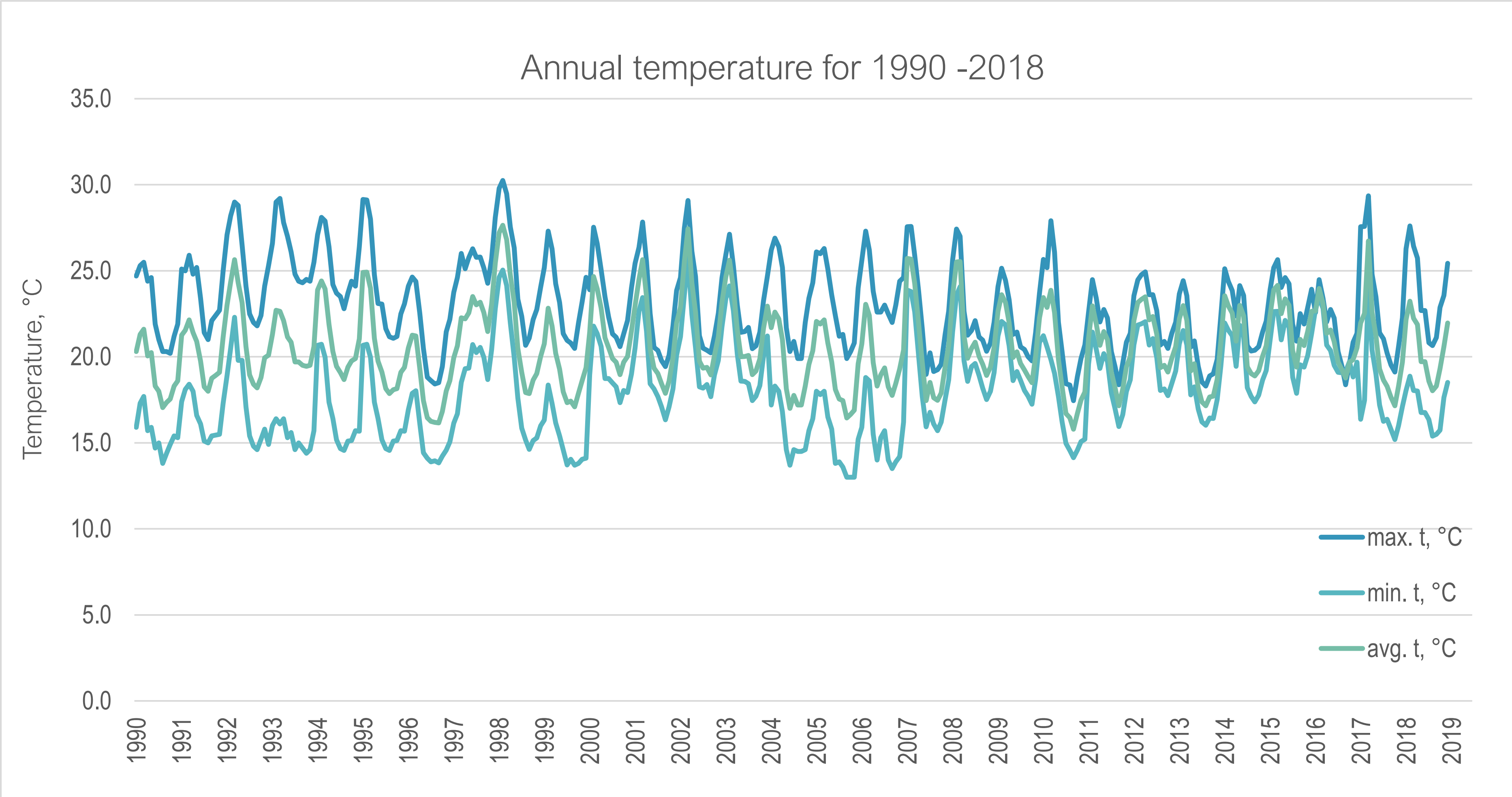


Figure 5. Annual temperature range 1990 – 2018 from the Huanchaco station (26 masl, 7 km from Trujillo) (SENAMHI 2019)

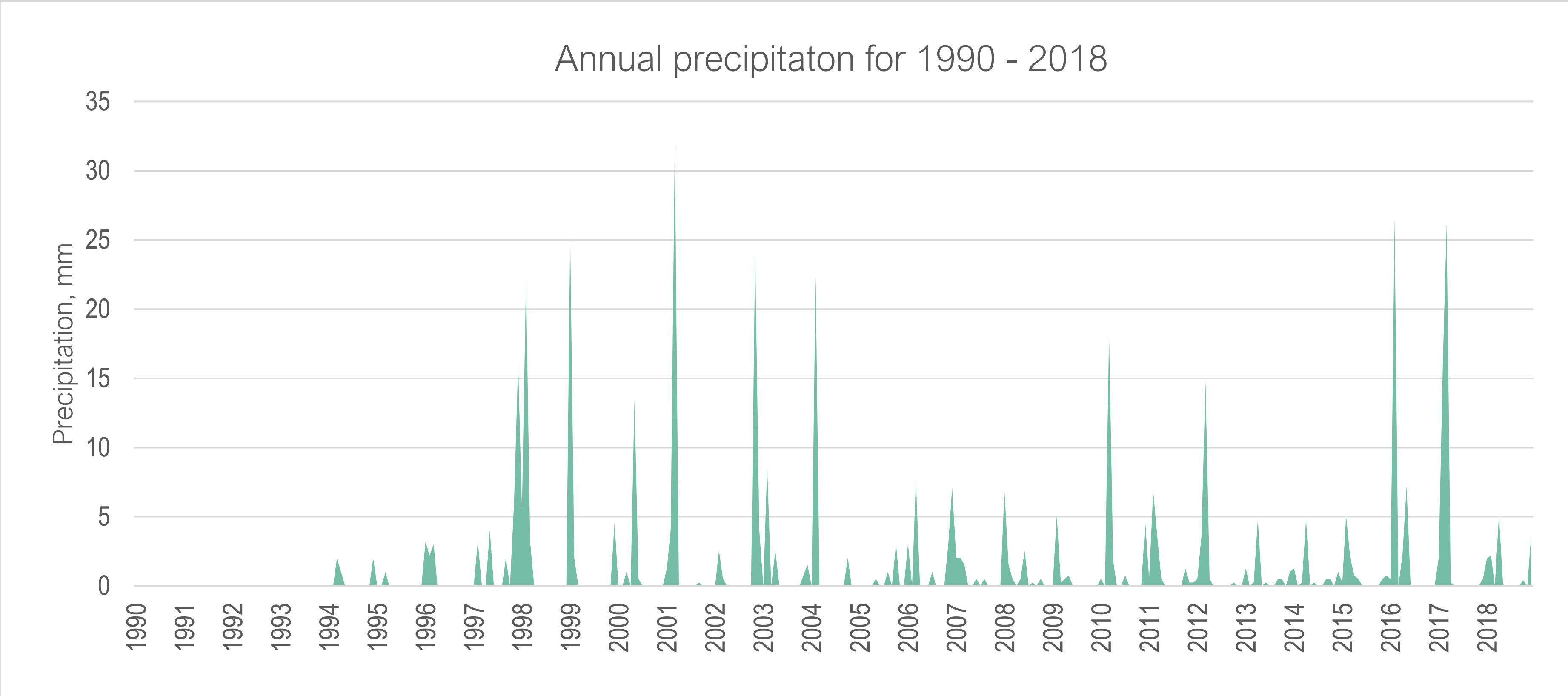


Figure 6. Average monthly precipitations for the period 1990 -2018 from the Huanchaco station (26 masl, 7 km from Trujillo) (SENAMHI 2019)

3.2.2. Hydro resources

Moche river and Virú river basins comprise in the catchment of this study. Underground aquifers are also present and used as a water source through number of wells. Beside the surface water and groundwater sources, the area is getting huge inflow from the irrigation channel. On the Virú river way next to the Virú town stands a hydropower plant (7,680 MW) which supplies power to rural areas in the catchment.

The Moche river

The Moche river origins in the Laguna Grande at 3,898 masl near the Quiruvilca town. The total drainage area to its mouth in the Pacific Ocean is 2,115 km² and the maximum length from its springs to its mouth is 110 km, an average slope is 4% (ANA 2013). The main contribution to river´s flow made by seasonal rainfalls, since the upper basin does not have significant snowfalls during the dry season. The river from its sources to its mouth has a sinuous shape. The main tributaries of the Moche river are: on the right bank: the Mótil (82 km²), Chota (98 km²), Otuzco (184 km²) Cumbray (496 km²) and Catuay (106 km²) rivers; and on the left bank: the Chanchacap river (122 km²). The maximum flow rate is 53.02 m^3/s, the minimum is zero, and the average 4.97 m^3/s (Figure 7), this results in annual average volume of 154,587 MCM (Figure 8). The highest surface runoff is present on the area with altitude greater than 1,500 m, which is about 50% of the basin. In the same time it is the area with highly developed mining activities, what has its impact on the environment via quality of discharged water (Burritt and Christ 2018).

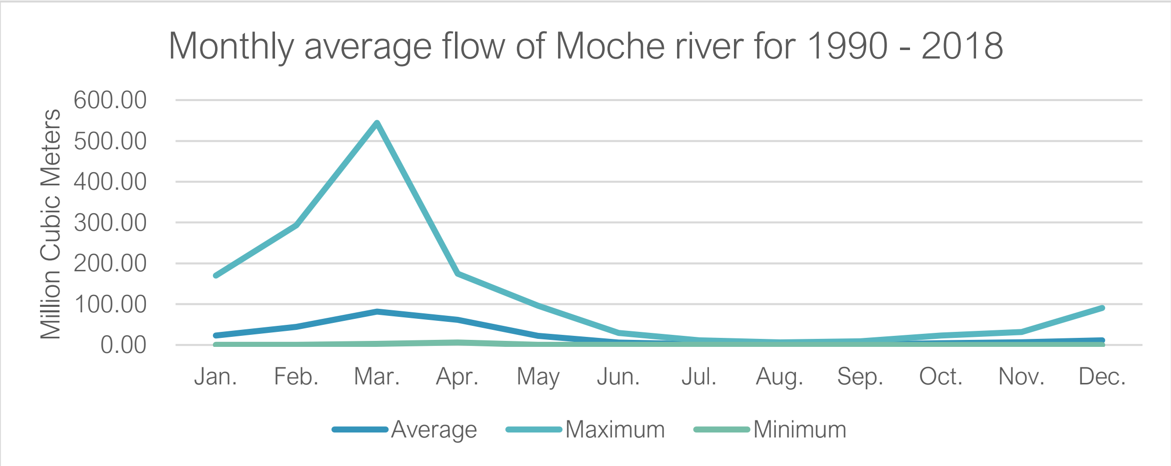


Figure 7. Monthly average flow of Moche river for 1990 – 2018 period, Cerro Blanco station (200 masl) (GRA 2019)

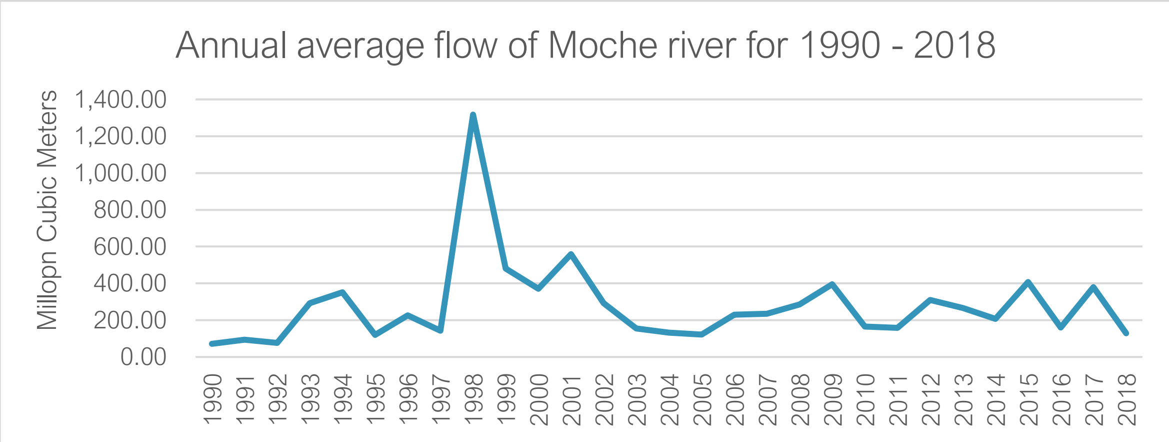


Figure 8. Annual average flow of Moche river for 1990-2018 period, Cerro Blanco station (200 masl) (GRA 2019)

According to the numerous water quality monitoring studies during the last decades, the Moche river suffers a constant contamination from different polluters: tailings from concessions minerals located in the upper basins; industrial effluents; domestic waste and sewage. Mining and other local industries do not have the appropriate measures systems for the final disposal of their effluents in the place, so everything is emptied directly to the river´s body (Vargas 2015; Sedalib S.A. 2018; INRENA 2000a).

The Virú river

Virú river starts from several lagoons located between the hillsides in the province of Santiago de Chuco. The Virú river longest path is 95.17 km with an average slope of 5% and a total basin area of 1,912 km^2 (ANA 2013). The tributaries located on the right side are: Pachachaca (110 km^2), Huacapongo (59 km^2), Carabamba (48 km^2), De Las Salinas (61 km^2) rivers; on the left is La Vega (12 km^2) river. According to the Huacapongo station´s records, daily discharge of the Virú river shows an average annual volume of 125,283 MCM (Figure 9), equivalent to 3.97 m^3/s (Figure 10). Likewise, Moche river, Virú river´s seasonal variations of discharge are depending on the precipitation that occurs in its upper basin and these are the primarily origin of the water runoff. Because there are no significant snowfalls, 69% of the total

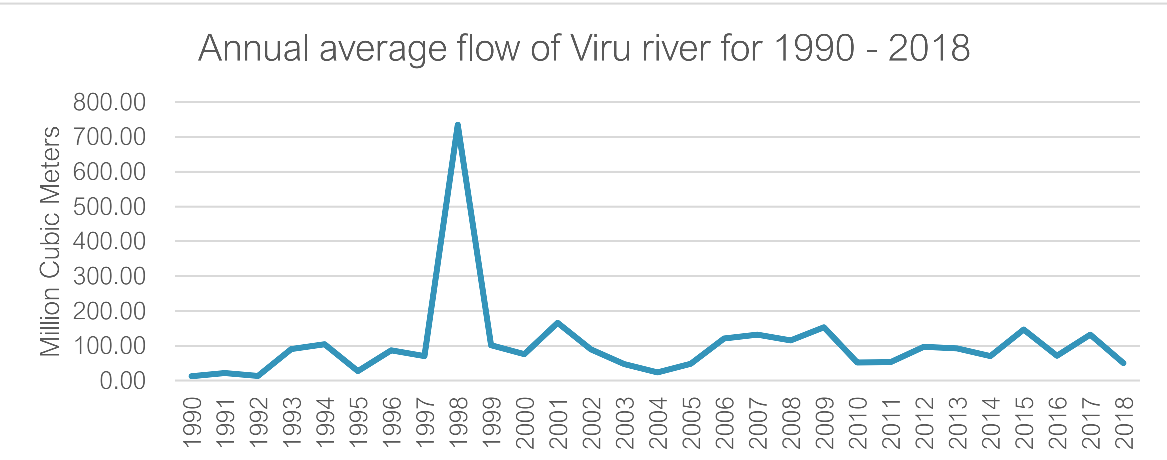


Figure 9. Annual average flow of Viru river for 1990 – 2018 period, Huacapongo station (280 masl) (GRA 2019)

annual discharge volume occurs during the floods period (from January to March), 14% during the dry season (from September to November) and the remaining 17% during the transitional period.

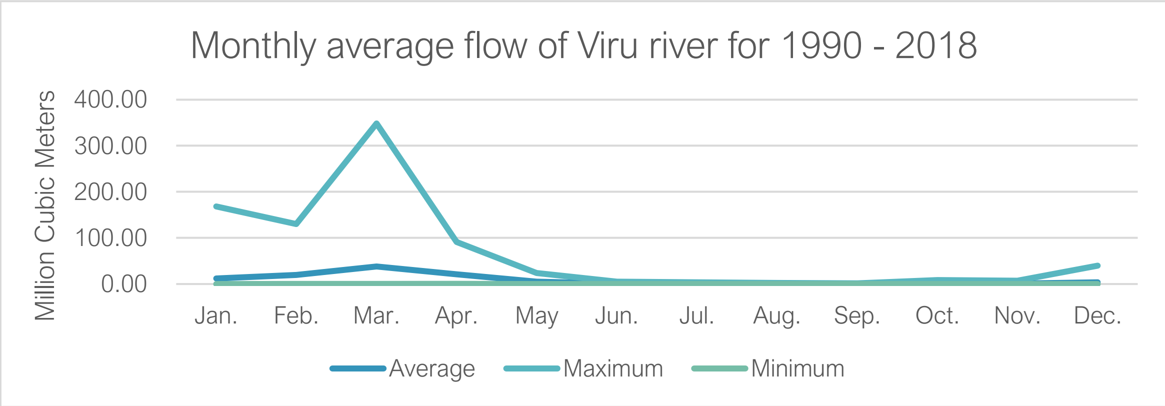


Figure 10. Monthly average flow of Virú river for 1990 – 2018 period, Huacapongo station (280 masl) (GRA 2019)

Groundwater

There are no recent studies on the aquifers in the catchment area, only outdated study from 1977 is available (INRENA 1977). It is known that the extension of the Moche aquifer is approximately 309,294 km^2 and covers districts of Trujillo, Víctor Larco, Huanchaco, El Porvenir, La Esperanza, Florencia de Mora, Moche, Salaverry, Laredo and minimally Poroto and Simbal (INRENA 2000a). ANA's archive has records about the groundwater exploitation and uses in 1981, 1998 and 2005 years (Table 5). It shows decreasing of use for almost 87% for Virú valley in the period 1981 – 1998 and for 50% for Moche in the same period. The explanation for such dramatical change is the Chavimochic Special Project, which started to bring water from neighbour basin of Santa river to the valley for irrigation purposes after 1993 and domestic use for Trujillo citizens after 1996.

Nevertheless, in the Moche valley alone, 1,365 wells have been identified by ALA in 2010 (Sedalib S.A. 2018), from which 1.54% is mixed, 17.44% tubular and 81.03% open pit. The Virú valley has recorded for year 1999 a total of 1,536 wells; of which 1,285 (83.66%) are open pit wells and 251 tubular wells (16.34%) (INRENA 1999b).

Table 5. Groundwater exploitation in Moche and Virú valley (INRENA 1999a, 1999a, 2000a, 2000b, 2005)

	1981		1998		2004	
Basin	MCM		MCM		MCM	
Virú Valley	77.68		10.11		N/A	
agriculture	74.66	96.11%	6.15	60.84%	N/A	
domestic	0.19	0.25%	3.59	35.49%	N/A	
other	2.83	3.65%	0.37	3.67%	N/A	
Moche Valley	57.23		28.08		17.30	
agriculture	18.51	32.35%	3.23	11.49%	0.70	4.02%
domestic	30.89	53.98%	23.47	83.58%	16.11	93.15%
other	6.83	11.93%	1.38	4.93%	0.49	2.82%

Wells were stopped being exploited and the water table became very high, because of water transferred from Santa river by the Chavimochic Special Project. Farmers prefer to use that cheap water source instead of pumping groundwater and spend money for energy and pump-related equipment. The raising groundwater level is causing the salinization of cultivated land and liquefaction of soils, which makes it necessary to perform horizontal drainage and vertical drainage regular, especially during the rain seasons (Sedalib S.A. 2018).

However, the main problem related to groundwater is the quality of water from the wells. The study from Sedalib S.A. shows, in 2016 water quality did not comply with the national maximum permissible limits (Sedalib S.A. 2018). It is observed that the indexes of sulphates, nitrates, conductivity and hardness are exceeding 250 mg/L, 50 mg/L, 1,500 µS/cm and 500 mg/L respectively. In some areas there was also presence of chlorides and arsenic. Due to that, water from wells could not be used for drinking purposes without pre-treatment. The quality of water also not suitable for irrigation of some sensitive crops.

The Chavimochic Special Project

The Chavimochic Special Project is governmental initiative with an aim to transfer and distribute water from the Santa river for the irrigation of 144 thousand hectares in the valleys of Chao, Virú, Moche and Chicama (Figure 13) as well as processing drinking water for Trujillo, benefiting at the same time locals with rural electricity services. From 1994 to 2015, a cumulative total of 56,225.60 ha has been transferred to the private sector at public land auction and direct sale, raising a total of USD 61 million income (CHAVIMOCHIC 2016b). Due to the report of 2000-2010, the project in annual average supplies 24 MCM of portable water, 24,988 MWh of energy and 122 MCM of water for irrigation (CHAVIMOCHIC 2012).

This water source has a primary importance for agricultural businesses in the area, it has water in sufficient amount whole year round. It needs to be mentioned, that average annual flow of Santa river during 2000 - 2010 is 137.8 m^3/s (Figure 11 and Figure 12), the river origins from the Conococha Lagoon at an altitude of 4,050 meters above sea level (ANA 2013). Besides the seasonal rainfalls, melting glaciers are important sources for the Santa river. However, recent studies are arguing whether that source of water is sustainable and will be available in the next few decades due to climate change (Mark et al. 2017). Nevertheless, the Chavimochic special project nowadays is working on its III Stage, which is about constructing reservoir for 400 MCM from the Santa river flow (CHAVIMOCHIC 2019).

The channel is very important because it secures water availability for crops, which cannot survive without it more then 1-3 days. Due to that, all private companies are using the reservoirs to insure the availability of water. Some of them are 20,000 m^3 at 5,000 m high, some are 17,000 m^3. Statistically, avocado fields need 15,000 m^3 per hectare per year or 41 m^3 per hectare per day. With this simple estimation, the needed amount of water for each field could be calculated.

Regarding the water quality from the irrigation channels, it requires just simple filtration from sand and other big particles before use for irrigation purposes. Water is fresh and not contaminated compare to the one from Virú or Moche rivers. The conductivity level also in the normal range (CHAVIMOCHIC 2019). The irrigation project office is getting samples of water quality more less regular (every quartal).

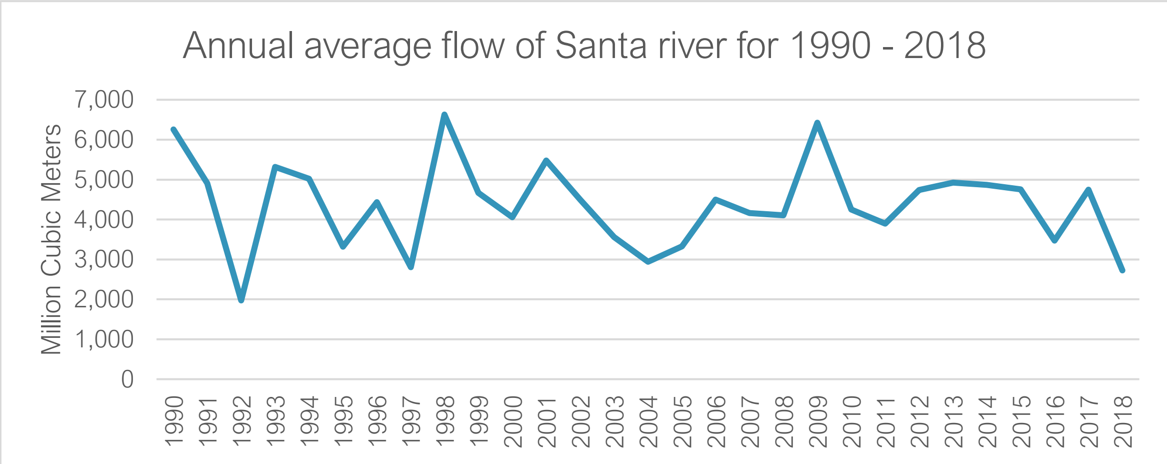


Figure 11. Annual average flow of Santa river for 1990 – 2018 period, Puente Panamericana station (430 masl) (GRA 2019)

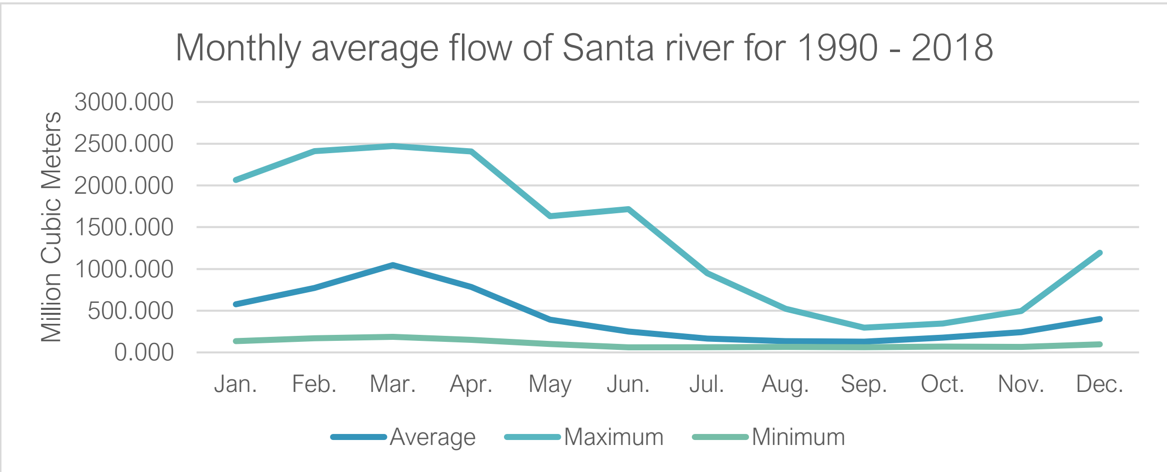


Figure 12. Monthly average flow of Santa river for 1990 – 2018 period, Puente Panamericana station (430 masl) (GRA 2019)

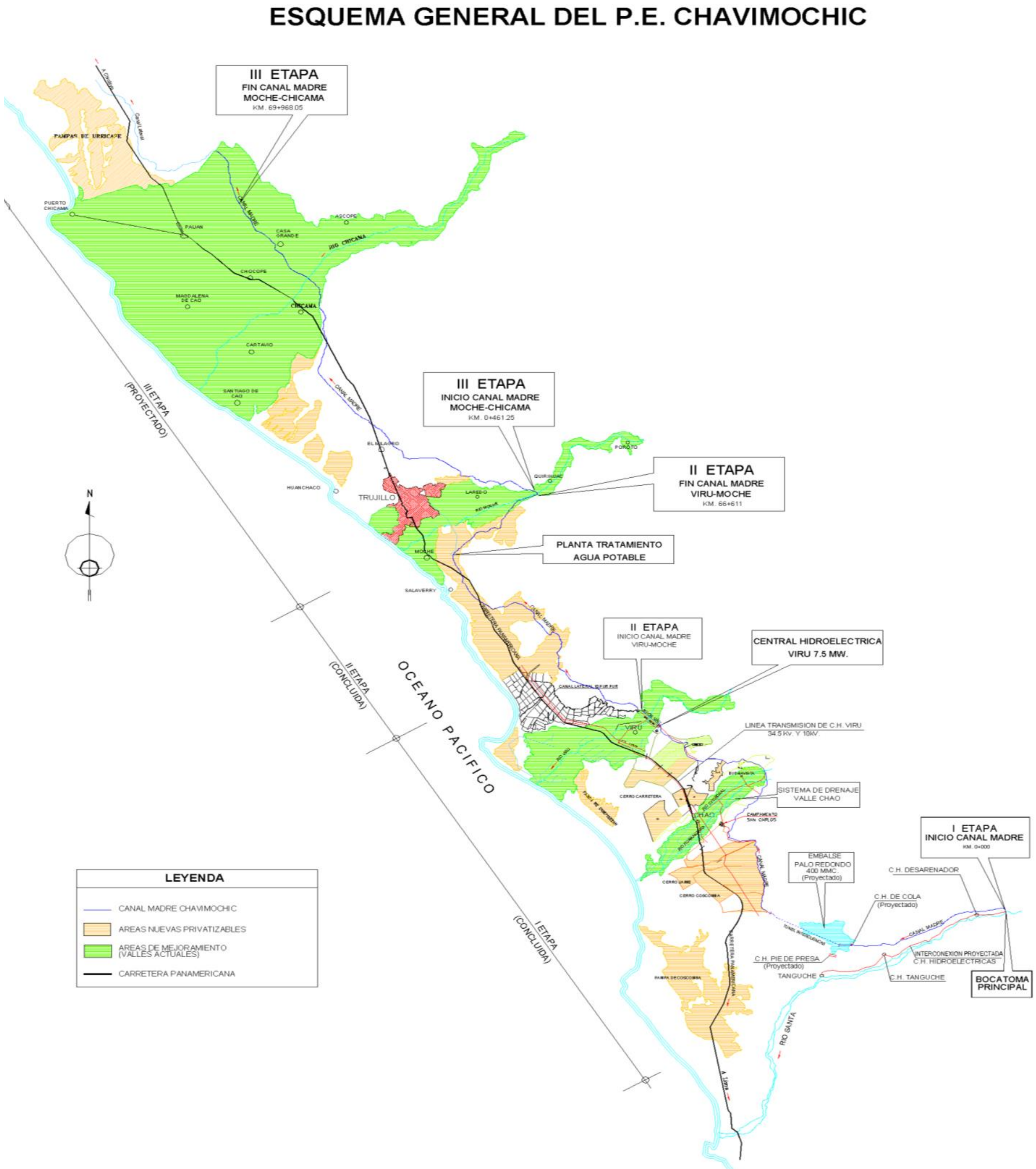


Figure 13. General description of Chavimochic Special Project (CHAVIMOCHIC 2019)

However, the region does not face water supply problem during the whole year. The exception could happen in two cases:

- For 1-2 days during August. It is the month with the lowest flow, 49 m^3/s. In that period the available water is not enough for everyone. The project administration is managing this issue by employing restriction on water usage. During such days, companies' managers are receiving the message with the time order, when they can irrigate their fields and how much water they allowed to use. Or as another solution, managers will receive instructions to irrigate not every day but every second day with special order. All this announcement could be found also on the web page of the Chavimochic project[7].
- During the heavy El Nino seasons. When heavy floods occur with mud slides and which ruin off everything else what were on their way, damaging fields, crops, storage and processing facilities as well as irrigation channels and reservoirs. In 2017 damaged channels were rebuilt in less than 10 days by the Chavimochic´s workers. It is also the reason why more or less all large companies are constructing backup reservoirs with a capability to irrigate for 1 week in emergency situation.

3.2.3. Hydrological extremes

Bridges destroyed by a river flood, mud stream demolished everything on its way, an exceptional thunderstorm and a single shower in the coastal desert, all these weather extremes are the signs of just one phenomenon. The El Niño-Southern Oscillation (ENSO) is an irregularly periodic variation in winds and surface water temperature over the eastern Pacific Ocean, which is affecting the climate of the tropics and subtropics. The ENSO has two variations: El Niño – when the temperature of the surface water is warming; La Niña – when the temperature is cooling. The two periods last several months each and normally occur every few years with different intensity (Larkin 2005; Rodríguez et al. 2005).

William Quinn was one of the first scientists, who started analysing and collecting records of the ENSO events, till now studies around the phenomenon are continuing, new variations are discovered (Rein et al. 2005; Diaz and Markgraf 2000). However, the earliest available records of this extreme are from 1525 - 1526 (Quinn et al. 1987). But the influence of recent climate change may have an effect on the frequency or strength of the ENSO (Collins et al. 2010). During the most recent strong events the coastal area of southern Peru, together with cordilleran region of southeaster Peru and Bolivia, experienced severe droughts. In the same time the coastal desert of northern part of the country suffered from anomalous rains. Moreover, according to the observations, these extreme rainfalls do not extents southwards to the latitude of Lima, but the peak is happening in the area of Trujillo province, which is next to the Company´s fields (Lagos et al. 2008).

During the examination of more than 250,000 pages of primary documents in the Archivo Departamental de la Libertad, scientists created the list of indicators that reflects the

[7] http://www.chavimochic.gob.pe/

ENSO event in the area (Garcia-Herrera et al. 2008). The list contains 24 indicators: starts with rain, failure of fisheries, high temperature, river flooding; and finishes with pests, damage to cultivated lands, change of prices, epidemics. Considering that, the precipitation variability in the study area could be also connected to the ENSO phenomenon (Lagos et al. 2008), in this study all hydrological extremes are considered as part of ENSO events.

In the course of 1990 – 2018 period just two strong phenomenon´s years were experienced in 1997 - 1998 and 2016 - 2017 (Ramírez and Briones 2017; Rein et al. 2005). They were characterised by heavy rains, caused river level rise, floods and huge mud streams which were destroying everything on their way. Rainy season is taking place every year, but the most important is to predict which year it will be strong, and which is regular. National and local governments were not ready for ENSO in 2016 - 2017, as well as population or businesses, lessons were not learnt from 1997-98. But scientists argue strong ENSO years could be predicted even 17 month before (Park et al. 2018), WMO Global Producing Centres of Long Range Forecasts[8] providing the information about global seasonal forecast including ENSO updates[9]. Nevertheless, closer to December the data is not changing, so people never know exactly if it will be strong El Nino or not. But local people can predict the El Nino, by observing animals' behaviour and can recognise when extreme weather condition is going to take place.

It is crucial to be prepared and have an emergency plan and a necessary infrastructure in place not only year before but all the time. Otherwise, it is unlikely to mitigate all consequences of extreme weather just in short period of time (French and Mechler 2017). From the Company´s view, a strong ENSO may result in damaged fields, storages, processing plants, irrigation infrastructure, yield losses and transportation problems. The impact of this event does not only have physical but also economic, social and regulation consequences. Those are discussed below under relevant sections.

3.2.4. Company´s impact on hydro resources

The Company´s processing plants depend mostly on groundwater extraction, wells, and partly on water from the Chavimochic special project. Estimated water consumption for processing plants is 1 MCM from groundwater and 0.15 MCM from the irrigation project. The Company´s wells have to be 50 m depth in 2007 in order to reach groundwater, but already in 2018 some of them started to have water at as close as 2 m depth. Regarding the water sources for the fields´ irrigation, the situation is the exact opposite, most of the water coming from the irrigation channel and groundwater is used just in an emergency situation. Nearly 12 MCM are used yearly for the fields´ irrigation. The reason for this, is to avoid additional costs for pumping and filtrating poor groundwater quality. The Company has several water reservoirs next to the fields, enough to supply all crops for 7 days, in case of an emergency situation.

[8] www.wmo.int/pages/prog/wcp/wcasp/LC-LRFMME/index.php

[9] http://www.wmo.int/pages/prog/wcp/wcasp/enso_updates.html

Liquid effluents, sanitary wastewater from the processing plants together with solid waste from the agricultural operation are the main sources of environmental pollution. At the beginning, effluents were not treated and not used to irrigate fields but discharged to the wastewater lagoon. After the start of collaboration with several international financial institutions in 2007, the Company started to work towards possible water use reduction and as a result, less wastewater was produced. Already in 2012, the amount of discharged effluent decreased by 12% compare to 2009 and resulted not only in reducing costs for water consumption but also costs for the water treatment. Moreover, the quality of discharged water was improved by reducing the organic load, so it became feasible for irrigation of crops for animals' consumption.

In 2014 a resource and energy efficiency assessment of the Company´s production plants was undertaken with the objective to optimize energy and water usage. The Company implemented a number of improvements (e.g., reuse of water for autoclaves) and reduced its water use for the processing plants by 30%. In 2017 a water treatment plant was constructed for the Company´s effluents from the processing plants. Moreover, the Company is minimising the impact on environment by using Integrated Pest Management and automatic irrigation system on the fields.

As a part of the conservation program, the Company conducts annual birds' identification and census surveys. In 2013 the Company reported positive impact on the biodiversity in the area of its operation, due to the rise of birds' groups and diversity of species. The implementation of Integrated Pest Management strategies reduced the use of pesticides and insecticides and, as a result it helped to achieve and support improved biodiversity.

3.2.5. Conclusion physical risks

Just 30 years ago the study area had a risk of droughts. There were periods when Moche and Virú rivers fell dry, but the situation changed after development of the Chavimochic Special Project. With the start of the water transfer from Santa river in 1991 to the Virú basin and in 1996 to Moche basin, agricultural business almost never faced water scares periods. Up to now, the irrigation channel always had enough water for all users. Nevertheless, recent studies of the Andes´ glaciers show, that they are experiencing rapid retreatment due to climate change. So probably the Santa river will have sufficient water for next 10 years, but for how long more?

The additional water also created problems to Moche and Virú basins. Due to poor drainage systems groundwater levels in some coastal areas of the basins grew, which created soil salinization. The yield started to be irregular, fields are flooded and groundwater has high level of salinity. There are several consequences for the Company as well: because of the poor groundwater quality, groundwater cannot be used directly for irrigation of sensitive crops (e.g., avocado, blueberries), just for the resistant crops, but not for long period (e.g., asparagus). On the other hand, it could be treated, but this brings additional operating costs for the Company. In addition, if water is not pumped, some parts of the fields will be flooded during the rainy seasons. Suitable drainage system should be in place to prevent high groundwater level and its consequences.

In the extreme scenario, when there is no water from the Chavimochic and groundwater cannot be used, the only source of water is the surface water from the rivers. However, as mentioned before, that amount cannot meet the demand from all current water users as of now. Moreover, water in Moche and Virú river is polluted by heavy metals from the mining activities upstream, industrial disposals, waste and untreated sewage. In 2018 National Water Authority by the Quality Management and Water Resource Assessment through the Technical Report Nº 250-2018-ANA-DCERH-AESFRH declared emergency of water resources in Moche river due to the heavy metals coming from tailings of the Quiruvilca mining unit (Licera 2018). So, the quality might be not suitable for crops or will make them inappropriate for human consumption.

The risks from extreme weather events as ENSO are high for the Company. The El Nino in 2017 resulted in damaged crops and fields, irrigation infrastructure, and yield was affected. Mud streams ruined just few hectares of irrigation pipes, but left hundreds of hectares several days without water, fertilizers and pesticides. It resulted in growing number of pests and diseases for the plants. Consequently, crops were harmed, irrigation system was broken, additional pesticide were applied that increased the costs for the business.

The Company said that the lesson was learnt and now it is undertaking such action as diversification of production crops and areas. As a result, the Company runs fields also in the other parts of the country, where the phenomena does not have a damage effects. In 2019 the Action Plan for El Nino was prepared by the Company, it includes protection actions for the plants, fields and operations. In order to assure the water for the irrigation of the fields, the Company planned to protect reservoirs with sandbags walls. Wells also will be ready for the operation at any time; warehouses will store additional amount of fertilizers and pesticides for 3 months in advance (in case of limited transportation).

The Company has a variety of physical risks due to its location and weather conditions in the region. It is also aware about most of them and undertaking some actions to mitigate or prevent them. However, there is still room for improvement, but it is important to understand that the Company prioritizes their actions, due to the costs of all mitigation measures to prevent the impacts of the hazards.

3.3. Regulatory conditions

Water management for agricultural purposes on Peruvian territories started more than 5000 years ago along with the Chavin culture. Already before the 16th century, Incas were constructing an advanced irrigation systems to supply around 700,000 ha with fresh water (Hill 2015). Some of that unique and progressive technologies are still operating, but most of them are used now just as a historic memory and tourist´s attractions. Despite their beauty, the water systems were built in situation full of water conflicts between users, which are always present in places where water is scarce, and demand is growing. This did not change with centuries, and current water issues in Peru have their origin from the colonial times (Alegría 2007).

That is why, proper water management was always important not only for Peru but for other nations as well. In case of Peru, where two third of the population rely on just 2% of all available fresh water in the country and share the same region with agriculture which is a main water user (nearly 80%), the situation is becoming even harder (ANA 2019). Taking in account also a rapid population growth and climate change, proper water resource management and a solid legal framework are important. Short term view and wrong governance system already pushed the Ica region (southern province of Peru) to its water limits. The exponential growth of non-traditional crops and agricultural practices resulted in a critical situation for all water users in the area. All of these because of the growing importance of the agricultural sector in generating foreign currency (Damonte 2019). Beside the fact that there is no more groundwater for extracting, government still issuing new extracting licences for agrobusinesses, which leads to protests from the local communities and the situation continues to be tense.

So strong water government practices in place are important for sustainable business growth and development as well as a possibility to have a voice as local user in the regional decision-making process. These and other essentials water policies can ensure businesses to put investments in water management and follow national legislations. Otherwise, if businesses are not sure about the fair water rules or if their neighbour company is following them, then willingness to play or act due to the rules ends. As a result, over extraction, pollution, soil erosion and many other consequences, which are leading to the dramatic costs for all water users, might even cause shutdown of the business (Damonte 2019; Alegría 2007).

3.3.1. Peruvian water management, law and policies

In the second part of the 20th century Peruvian government started to invest in irrigations projects, due to the important role of agriculture in country´s economy. Furthermore, as agriculture was the largest water user, the Ministry of Agriculture was appointed as "National Water Authority" in according to General Water Law No. 17752 (Ley General de Aguas) issued in 1969 and was responsible for water resource management, mainly quantitative part and the Health Ministry for qualitative part (Peru Support Group 2008). The whole water governance was fragmented for different sectors (e.g., agriculture, mining, hydropower) but had centralised administration with little power for stakeholders at the local level. That General Water Law was in power almost 40 years, its main features were (Alegría 2007);

- Water resources are property of the State;
- Water rights transfers are prohibited;
- Law is biased to agricultural use (irrigation) and to the coast region conditions;
- Customary law in Andean region is ignored and not acknowledged.

There was no attention for water quality, some conflict regulations and a lack of compliance. Therefore Peru faced water pollution problems in 1980´s from uncontrolled emissions of the mining sector (Eda and Chen 2010). Situation started to change in 1990´s after the number of regulations and laws passed in order to create administrations for natural capital conservation. In 1991 Legislative Decree 653 presented a law for promoting investment in the agriculture, so water became more economical good then public right. In 1992 the Institute of Natural Resources (INRENA - Instituto Nacional de Recursos Naturales) was created by Degree Law No. 25908 under the Ministry of Agriculture administration. Its main objective is the sustainable use of renewable natural resources, the conservation of wild biological diversity and the sustainable management of the rural environment (Peru Support Group 2008). Nevertheless, water quality questions were kept under the Ministry of Health responsibilities, which were still creating several overlapping and mismanagement problems between agencies in the water sector. In addition, since 1992 mining industry started to grow rapidly and between 1990 and 2005 was responsible for around 50% of all country´s export. Consequences of this expansion were noticed by downstream communities in a water and air quality (Figueroa B. et al. 2010; Eda and Chen 2010). The government introduced in 2002 the Nineteenth Policy of the National Agreement (Décimo Novena Política del Acuerdo Nacional), with main goal to shift water management to the basin level and stimulate the environmental investments. Due to the literature review, down stream's people did not feel the difference in water quality or improvement in environment conditions. Partly because the main water law were still the same, from 1969, just with some additions (Eda and Chen 2010).

But it was the start of moving towards decentralization, in 2003 a Decentralization Law, then a Regional Government Law, a Municipal Law were issued. Despite the limited resources in local governments, they begun to be responsible for water quality management, operating and maintenance of public infrastructure (Yacoub et al. 2015). But the whole legislations and management were difficult due to old and outdated Water Law from 1969 and numbers of laws to support it (Peru Support Group 2008). Following that changes the Ministry of Agriculture, in a collaboration with Ministries of Farming, Defence, Economy and Finance, Energy and Mines, Housing, Construction and Sanitation, Health and Production, released together a National Water Resources Management Strategy draft in 2004, with aim to promote integrated resource management practices (MINAGRI 2004). In addition, the Program for the Formalisation of Water Use Rights (Programa Extraordinario de Formalización de Derechos de Uso de Agua) was implemented under the Ministry of Agriculture, with an aim to grant formal water rights to 200,000 properties in 35 coastal valleys (French 2016). As a next step in 2005 was a creation of the Technician Irrigation Program (Programa de Riego Tecnificado) that promoted the progressive replacement of traditional irrigation systems in the agricultural sector in general. Nevertheless, the situation`s improvement was very small.

The State started to develop a Program of Water Resources Policies (Programma Políticas de Recursos Hídricos PE-L1024) in 2007 with a help from international funds with the general goal to improve the efficiency, fairness and sustainability of the usage and exploitation of water (French 2016). In the overview of the challenges of water resource management in Peru as on 2007, author Alegria mentioned several related problems (Alegría 2007):

- Inappropriate water law framework for communities of the Sierra and Jungle regions, little support of agricultural development;
- Laws and regulations were not adjusted for the departments and provinces outside of Lima;
- Indigenous water rights were neglected;

- Huge investment in large scale irrigation schemes with few results
- Low productive agriculture due to low yield crops allocation;
- Subsidized water tariffs for domestic and agriculture.

Unofficial water use was known by the government, but the situation remained the same. According to MINAGRI´s presentation from 2008 document, water consumption by agriculture was 85% from the total, the irrigation was responsible for 80% of that amount, and 95% of it was made by gravity technics. But the same document stated that the efficiency of such irrigation methods was just 35% (MINAGRI 2008).

On March 2008 by the Legislative Decree No.997, National Water Authority (ANA - Autoridad Nacional de Agua) was created under the Ministry of Agriculture, this public body is in power till now (2019) as well. It replaced INRENA and became responsible for the integrated and sustainable water resource management. On May of the same year the Peruvian Ministry of the Environment was established (Andersen 2019). Moreover, during the summer 2008 government started working on a new Water Law, but it provoked street protest. People were mostly disagreeing with the governmental draft; their main fear was in moving water rights form the State to the private sector. After numerous discussions with different stakeholders, just after one year, in 2009, new Water Resources Law 29338 were passed into law (Eda and Chen 2010). The Law 29338 recognises water as the national heritage, prohibited the privatisation of the resource (article 2), but in the same time promote the participation of the private sector in construction, improvement, maintenance and operation of the hydraulic infrastructure (article 105) (French 2016).

After introducing 2009´s Water Resources Law, Peru started the reorganisation of its water-governing institution. The main organ for water resources management (including water quality questions) became ANA with the main office in the capital, 14 Regional Water Authorities (AAA – Autoridad Administrativa del Agua), govern several Local Water Authorities (ALA – Autoridad Local del Agua) which exist at the level of river basins. According to Water Law 29338, water resource management transferred to the river basins, where different water users involved in management through river basin councils. Nevertheless, the administration of financial resources and water tariffs is the responsibility of centralised ANA and its regional offices. Worth to be mentioned that the establishment of that new water management structure was financed by the World Bank and the Inter-American Development Bank (World Bank 2017). This project is still helping Peruvian government to establish 10 of the 156 river basin councils.

The whole system is still on its beginning stage, many basin councils are yet to be created, many people should be trained and introduced to the integrated water management principles. According to some authors, the new law and new water government structure were not received positively by some stakeholders. Farmers argue that new regulation give more power to big agrobusinesses and mining companies. They have now to prove the efficiency of their water use to the government but so far did not get such evidences from the government. Communities from highlands are feeling that their indigenous water rights and principles were removed (Andersen 2019; Eda and Chen 2010; French 2016). On May 13th in 2019, thousands of middle and small farmers waved the country with several massive strikes, demanding to withdraw Law No.30157, which related to the management of water resources. They claimed, the law gives ANA more power and could be the first step to the privatisation of water resources (Peoples Dispatch 2019).

3.3.2. Local water regulation

The ALA of Moche, Virú and Chao rivers is responsible for the study area of Moche and Virú river basin from ANA. Water management council in the Moche and Virú basins is organised by farmers as the Moche River Users Board (Junta de Usuarios de la Cuenca del Rio Moche), the Virú River Users Board (Junta de Usuarios de la Cuenca del Rio Virú) in addition, the Board of Water Users of the Minor Moche Hydraulic Sector (Junta de Usuarios de Agua del Sector Hidráulico Menor Moche) (ANA 2019).

Moreover, there is the Pressurized Irrigation Users Board for Moche Virú Chao Valleys (JURPDRMVC – Junta de Usuarios de Riego Presurizado del Districto de Riego Moche Virú Chao), which was established in 2004, with an objective to promote efficient water use, distribute water equally to farmers, and to achieve permanent participation of the water users in operation and maintenance of the irrigation and drainage infrastructure as well as in the development, conservation and preservation of water resources in their territorial jurisdiction (JURPDRMVC 2019). The Company is one of the 55 members of this board. The webpage[10] of the Board provides methodological information in the region and statistic of the Santa river (for Chavimochic special project users). Moreover, it organises trainings for members in water efficiency and new irrigation technology topics.

JURPDRMVC is responsible for maintenance of the irrigation channels. However, almost all of the irrigation channels (except of the Chavimochic main channel) are suffering from leakage losses which are leading to non-efficient water usage. This is the result of the lack of financial support for local water government (Andersen 2019). Moreover, regular cleaning and repairing on the main irrigation channels are not taking place, only in emergency situations (e.g., damage after mud stream during strong El Niño years)(Vargas 2015).

3.3.3. Water pricing

Water tariffs in Peru used to be very low, so they are now. They are not meeting all cost recoveries, as was mentioned before, it is even not enough for regular maintenance of the irrigation channels. Furthermore, water rates do not include the environmental costs. Such low tariffs could be explained by number of reasons (e.g., political considerations, legal restrictions, information problems), nevertheless, one of the reasons is low rate of actual payments by users and a poor measurement system of used water. The situation is slowly starting to change with the help from international organisations (TNC 2015; Lehmann 2010).

In this study, just water tariffs for irrigational use will be discussed, this includes water from the Moche and Virú rivers, groundwater and supply from the Chavimochic special project. Tariff for Use of Major Hydraulic Infrastructure (TUIHMA - Tarifa por Utilización de

[10] http://www.jriegopresurizado.org.pe

Infraestructura Hidráulica Mayor) does apply for users from the Chavimochic main channel, and Tariff for Use of Minor Hydraulic Infrastructure (TUIHME - Tarifa por Utilización de Infraestructura Hidráulica Menor) does apply for using small irrigation channels (mostly connected to the rivers Moche and Virú, but some have access to the Chavimochic irrigation project as well). With the Resolution No.353-2018-ANA-AAA H CH/ALA MVCH from 2018 users of minor irrigation infrastructure, which are getting water from the Chavimochic, should pay just one bill to the Chavimochic (including both tariffs). The irrigation project must transfer the money to the ANA account in the end of the year. The same Resolution also states that TUIHME for 2019 is 0.070 PEN/m^3 (~0.01 EUR) for Moche basin and 0.062 PEN/m^3 for Virú (ALA 2018).

In the case of water distribution from the Chavimochic channel, due to the lack of measurement and controlling capacities, each agricultural company has an exact water volume for use in according to the owned irrigated land. So, the water tariff for the Company is based on the owned land multiplied by the approximate water use and costs for cubic meter of the water. According to the Chavimochic report for 2000 - 2010, water tariffs were 0.065 PEN (~0.01 EUR) per cubic meter in 2000 and went down to 0.036 PEN/m^3 in 2010 (CHAVIMOCHIC 2012).

The Chavimochic special project water tariffs are decided by the project committee. The members are representatives from the agricultural businesses. Big farmers have a cascade price paying system, which depends on the amount of consumed water. The TUIHMA tariff in 2015 was (CHAVIMOCHIC 2016a):

- <10,000 m^3/ha/year – 0.057 PEN (0.016 EUR)
- 10,000 – 13,000 m^3/ha/year – 0.088 PEN (0.026 EUR)
- >13,000 m^3/ha/year – 0.189 PEN (0.055 EUR)

All users of the irrigation project sign the Declaration of Irrigation Intensity, which oblige them prior to the start of each annual agricultural campaign to announce the number of hectares that be will be used for agriculture. According to declared amount they are assigned water volumes for irrigation. Small farmers have a different tariff system compares to larger users, which have even lower tariffs. Keeping these tariffs in mind, one can deduct that the financial resources are not sufficient for the operation and maintenance the whole irrigation project.

Regarding the groundwater tariffs, in 2016 the National Superintendency of Sanitation Services (SUNASS – Superintendencia Nacional de Servicios de Saneamiento) started a project in a collaboration with World Bank for development of new groundwater tariffs. Lima and Trujillo were chosen as pilot cities to introduce the new tariff system (Pham 2016). Due to the report in 2018 a new tariff plan with 0.906 PEN/m^3 (0.24 EUR/m^3) was presented for groundwater users in the Trujillo province with Sedalib S.A. company (Andina 2018b).

3.3.4. Company's water management

The Company uses drip irrigation technics from the beginning of its operations, this was a condition of the contract for water supply with the Chavimochic Special Project. Today the Company has an automatic system for watering the crops with a weekly schedule. The schedule is based on the methodological prognosis for the area.

Since 2011, the Company started an implementation of the Clean Production Programme with an aim to reduce the water usage and reduce the effluent production per kilogram of dry product. As part of the programme, the cooling towers were installed to facilitate the recycling of autoclave condensate what reduced water effluents by 30%. Regarding the groundwater use, the Company has installed remote control computer-based groundwater level control sensors in each well in 2009 to monitor future trends in groundwater availability. The Company has licences for about 2 MCM annual water extraction from ANA in place and is regularly updating them.

Before reaching the field, water used for irrigation is mixed with fertilizers and other chemicals needed for higher crop´s productivity. The Company applies just EPA[11] and GlobalG.A.P.[12] registered pesticides, nutrients and chemical fertilizers, composed manure for crops. The Integrated Pest Management was set up in 2009 by the Company´s management and as a result the pesticide expenses were reduced by 39% already in 2012.

As part of JURPDRMVC, in 2013 the Company helped to maintain the drains network, which lead to a significant decrease of the water table and improved the productivity of the soil.

In 2015, the obligation from a national government policy was to construct a water treatment plant for its production effluents. So, the Company started a tender for contractors to build a state-of-the-art wastewater treatment plant. The plant started to operate in 2017 with a maximum capacity of 12,000 m^3/day. As for today (2019), the Company is working towards its Resource Efficiency Management Plan and looking for improvements.

3.3.5. Conclusion regulatory risks

To summarise, the Water Resource Law has good water management approach and values, but it is still meeting difficulties in the implementation on the regional and local government levels. Due to limited capacities and disorganisation, it is not been followed properly. Another important point is the governmental structure. Since the Ministry of Agriculture is responsible for ANA, it is obvious that agrarian sector has more privilege and influence in water questions than other sectors, so an integrated management approach cannot be realised completely. However, ANA might move under the Ministry of Environment control after it become fully operational (French 2016). This promise was mentioned during the establishment of ANA and creation of the new Water Law. The Ministry of Environment in Peru is already working more than 10 years, but transfer has not yet occurred. This is one of the regulatory risks for the Company. If the government structure of the water governance would change, agriculture could lose its privileges and influence.

[11] https://www.epa.gov/data-standards

[12] https://www.globalgap.org/uk_en/

Just few decades ago, the government was securing water rights for landlords with management under the central State. Today, with the new law, preferences are shifted to large-scale agro-export and mining sector companies (Andersen 2019). Rising dissatisfaction from small and medium scale farmers could change the water management in the country or at least bring difficulties for government and large agrobusinesses. The situation may seem not so critical when the water is abundant. But regulatory water related risks also may result in forced changing of the water source (e.g., from the Chavimochic to groundwater) or irrigation technics. This could be part of new water governance policy due to the water future scarce in the region or any other political decision. These obligatory changes would require fast reaction from the Company´s management and would result in financial costs. The new water sources would demand new infrastructure and might bring some delays in operation due to construction. The expenses related to change of irrigation technics might need also include new employees, who are specialised in new system.

3.4. Reputation conditions

It is critical to know who the stakeholders are, who can be affected by Company´s water actions and other way round. Reputation risks related to the water topic could be directly depending on the Company´s operations (water management practices) or be completely independent (extreme weather events). Nevertheless, the more business is aware about the water users and their needs, the better it could prepare itself for possible reputational risks connected with water management. In the past there were many examples, when business could not operate due to concerns of local communities about its water management actions: e.g., a closed Coca Cola factory in northern India (Chilkoti 2014), Chilean avocado producers faced water war in the Petorca city (Facchini and Laville 2018), Peruvian southern coastal province of Ica fighting for the water resources since 2000s (Damonte 2019). UNEP reported that more than 70% of the social conflicts are conflicts for environmental issues (including water management) (UNEP 1999). World Economic Forum stated that in 2017 water was a major reason for conflict in more than 45 countries (Heijden and Stinson 2019).

3.4.1. Water users

In the study area, the Company is sharing its water resources not only with other agrobusinesses but also with mining industries, local communities, livestock activities and the environment. Nevertheless, agricultural water demand is the highest, followed by the population, industrial, livestock and mining usage. However, water usage has a different pattern in the lower and upper parts of the studied basins.

The lower basins of Moche and Virú river has mainly urban population. As mentioned before, Trujillo is the third biggest city in Peru. The population growth in the coastal cities and peripheral districts has been greater than the rate of vegetative growth explained mainly due to migratory flows from the countryside to the city. The water supply company from the Trujillo province conducted studies to estimate the water demand for the growing population (Sedalib

S.A. 2018). The results show a rise off 67% (around 141 MCM) in 2046 for domestic usage and the same percentage for agricultural purposes (about 272 MCM). Agrobusinesses are the main economic activities in the lower basins and it is expanding rapidly as a result of the hydraulic infrastructure of the Chavimochic Special Project.

Rural population prevails in the upper basins and agricultural activities is present in the terraces or in the Andean valleys where some area used for pastures. However, the irregularity of rainfalls as well as topographic inconsistency are making development of such activities difficult in the area. Despite these challenges, mining industry is continuing pollution at a high level in the highlands of the study catchment.

Agricultural usage

The main water user in the catchment is agriculture with responsibility for more than 80% of all water demand. Most of the irrigated agriculture is located in the lower basins, near the coast. The main crops grown in the valleys are: sugar cane, corn, alfalfa, pineapple, yucca, asparagus, beans and avocado (GRA 2019). Nevertheless, it is difficult to estimate the real numbers of water consumption by agrobusinesses, because of the lack of up to day statistics. Basins´ study from 1996 stated, that 268.15 MCM were used for irrigation at that time for around 20,200 ha of fields located in the coastal part of the basin and for 11,000 ha in the upper humid basins (INRENA 1996). This accounting includes all water sources available in the region. More recently, in 2010, the irrigation project Chavimochic has reported their water supply for agricultural purposes in the Moche and Virú valley as 89 MCM for more than 20,000 ha (CHAVIMOCHIC 2019).

During the field research and personal communications with representatives of agricultural sectors it brings to conclusion that, the main water source for big farmers is the Chavimochic Special Project. It worth to be mentioned, that water could be used just through drip irrigation as it is contractual obligation (CHAVIMOCHIC 2019). In addition, some of the companies have wells as an emergency water source, but they are rarely used because of the continuous water flow in the irrigation channel. During the rainy season groundwater level is getting so high that fields in the lower elevations are experiencing liquefaction of soils, as it was mentioned before in the groundwater description paragraph. In those situations, companies are even asked to use more water from their wells to bring the groundwater level down again. The main obstacle for the use of groundwater is its quality, which has high salinity level, not suitable for most of the commercial crops (e.g., avocados, blueberries). Groundwater could just be used for a part of the crop portfolio (e.g., asparagus, sugar cane, corn). For other crops it should be treated before using, what brings additional costs to the companies. Therefore, big companies will more likely be using fresh and cheap water from Chavimochic as long as it has a sufficient flow. Middle size and small farmers rely on surface water from rivers during the rainy seasons (January - April) and switch to ground water when rivers do not have sufficient flows.

Public usage

The most significant provinces in the study region are Trujillo, Ascope, Otuzco and Virú. The population in Moche and Virú basins currently exceeds 1.3 million inhabitants (INEI 2017). All these people depend on different water sources for their domestic needs. In the rural area on the coastal areas the supply is normally from wells and in the mountain´s areas normally from springs, with no statistical data of consumption. Drinking water systems in the rural area of the Sierra are operated by gravity without treatment and on the coastal area population getting water through wells, rarely with simple home treatment systems. In the case of Trujillo province in 2018 for domestic purposes were used 87.52 MCM, 46.64% of which were supplied by groundwater and 53.36% were complemented by the Chavimochic Special Project portable water plant.

Industrial usage

Industry enterprises are present mostly in coastal cities, they are mainly food and beverage productions sites. The shoe industry also has an important cluster in the outskirts of Trujillo. There is lack of the recent consumption statistic, but study from 1996 reports 2.08 MCM for this sector (INRENA 1996).

Livestock´s usage

The use of water for livestock was amounted as 1.2 MCM, but also just for 1996, due to lack of present data (INRENA 1996). Main users, following in order of consumption, are: cattle, horses, pigs, sheep and goats.

Mining´s usage

Water is consumed for mining purposes, to treat minerals such as Cu, Pb, Zn and Ag. Mining activities are located in the upper basin of Moche river, next to the Shorey town. The actual amount is unknown, but in 1996 it was 0.58 MCM (INRENA 1996).

Environment

The lower basin of the Moche and Virú rivers naturally contain premontane desert flora. The riparian forest, as a typical formation of the riverbanks, covers the entire riverbank where the Moche and Virú rivers flow and is characterized with perennial communities of herbaceous plants, climbers, shrubs or trees. Most of the area next to the coast is covered by croplands.

The most characteristic species of this area are: *Gynerium sagittatum, Phraymitis autralis, Tessaria intergrifolia, Baccharis glutinosa* and *B.Salicifolia.* These shrub together with some low trees, are sometimes found on stony fields or forming fences between field. *Phraymitis autralis*, known as "Carrizo ", are occupying a great part of the marginal strips and rivers´ bed in its low areas (Vargas 2015). Many of these species are and were used as construction materials, in domestic activities and handicrafts (pottery, utensils and instruments). Vegetation in the rivers´ banks also have a protecting function for erosion caused by the natural flow and floodings.

There is also the presence of wetlands in the scope of the study area, which is used by birds as a resting point during long migration journeys; used as freshwater storage and as aquifer rechargers. Some of them are declared by the Regional Government La Libertad as a protected areas (e.g., the reeds of Huanchaco, the Huanchaquito wetland), according to Resolution No. 005-92, in the extractive reserve category and serve as aquatic ecosystems and rest of migratory birds (Vargas 2015). In the upper basins several lagoons are the source of water for local communities, fish and birds.

3.4.2. Agriculture in Peruvian GDP

The Company operates in relatively new for Peru export-oriented agricultural business sector. This field started to rapidly develop around 30 years ago in the country, due to construction of large irrigation projects (e.g., Chavimochic). According to the World Bank, in 2017 agriculture constitutes 7.3% of Peruvian GDP, around USD 15.38 billion (World Bank 2019). Agriculture contributes annually between 9.5 – 7.3% to Peruvian GDP, if look at the statistics for 1990 – 2017, with an average grow of 3.3% per year in 2000 - 2015 (Morris et al. 2017). In the same time the World Bank Country Director for Bolivia, Chile, Ecuador, Peru, and Venezuela, Alberto Rodriguez, argues, that in reality numbers are much higher for 2017, agriculture contribution were around 11.3% only for 2012 data (Andina 2018a).

Furthermore, according to the Ministry of Agriculture and Irrigation, in 2017 the agricultural sector was the second largest generator of foreign currency in Peru after the mining industry, and were responsible for 27% of total employment in the country (World Bank 2019; Oxford Business Group 2018). Experts also believe, that agricultural companies could help to solve poverty problems in Peru, providing constant income to employees´ families (Morris et al. 2017). Before mentioned Mr. Rodriguez said, that in the last decades this sector generates one of every four legal jobs in the country.

However, agricultural sector does not develop equally in the expanses of whole Peru. It is the coastal part, which has more big farmers with technologies and plantations of high-value crops (including export crops), big governmental irrigation projects like Chavimochic, brought new opportunities for the agricultural sector in this region. It is also one of the reasons for internal migrations of some Peruvians (Yamada 2010), who left their small farmer businesses in the highlands and moved to the coast to work in large agricultural companies.

As a result, demographic growth combined with rapid urbanization is leading the rise of the population in coastal cities which results in increasing competition for land and water resources. Within the study area, around 10 big agrobusinesses are located, which generate more than USD 2.7 billion in export revenues during 1990 - 2011, and according to the information from the Chavimochic Special Program, thousands of additional hectares will be converted to fields within the III Stage of the project (CHAVIMOCHIC 2019).

3.4.3. Working conditions

The Company complies with ILO core labour standards and other international working regulations (e.g., working hours, remuneration). It committed to recruit workers mainly from nearby communities. The yield collection is mainly manual with around 3,500 full time employees and a limited use of machinery. Since 2006 the Company converted all seasonal workers to full-time workers, carrying out harvesting and maintenance work during the whole year. The workers work up to 60 hours a week during the high season (December - March), which is standard for the sector and in accordance with local labour regulations. Workers are allowed to form or join worker´s organisations and to bargain collectively. The Company ensure that child labour or forced labour is not used directly or through contractors. Due to the report from 2018, the Company´s minimum wages are 15% higher than the country´s average wages.

The Company has an OHS policy in accordance with international standards (i.e. OSHAS 18001). An OHS risks analysis by external experts is conducted every year. All employees are provided with trainings and personal protective equipment relevant to their assignments. In addition, there are soft and hard skills trainings available for all employees (e.g., in water savings and management).

3.4.4. Social responsibility

The Company is actively engaged with communities from the day of establishment. In 2005 a Social Responsibility Department was created to formalize the engagement with the community. The Company has a commitment to improve the social development in Peru by providing direct or indirect employment for local communities, promote health, prevent malnutrition, and provide medical service assistance to all employees and their families. In addition, it has a housing program to help workers own a home, children educational programs during the summer holidays and children´s Christmas celebrations. For the social programs the Company is spending annually about EUR 1 million.

The Company is supporting small rural farmers in the highlands of the Moche and Virú river basins by buying their products via formal contract. This is the source of income for small producers, which encourage them to stay on the land and not move to urban provinces. As a part of the contract, farmers are getting an access to trainings, finance and information about the latest technologies, allowing them to develop strong agricultural production and be a reliable supply for the Company.

During the El Nino years, the Company helped local communities with clothes, construction material for rebuilding houses, providing drinking water and reconstructing the infrastructure. The internet search and a RepRisk[13] analyse did not show any conflicts in the water topic which was caused by the Company´s operation in the region.

3.4.5. Conclusion reputational risks

The Company is providing thousands of jobs for the local community, moreover, most of the workers are unskilled with nearly 50% are women. This could be seen as a positive impact on local development and on decreasing poverty. Also, the Company has a large social responsibility program, which is beneficial for workers and their families.

Active engagement with local community is important for the Company reputation and this is also ensuring a stable operation. Regular reporting regarding the environmental impact (including water resources) is an important part of communication with other stakeholders.

[13] https://www.reprisk.com/

Till the time of this study, there were no complains or disagreements between the Company and other water users in the studied area. There were no negative social impacts identified, which were caused by the companies operating in the Chavimochic Special Project. At the moment social water related risks could arise for the Company and there may occur a need to pay a compensation to society for the negative environmental impacts. The situation might change with a critical rise of the groundwater level due to the water transfer from another basin and due to the violation of the water balance in the basins. Or it may change due to water pollution from the fertilizers and pesticides use by the companies in the region.

4. WATER RISK ASSESSMENT TOOLS

During this study 130 different tools, frameworks, standards, guidelines and other approaches were reviewed to put a value on water and in some cases to assess water risks as well. The goal is to check if monetarising water value technique might be used for putting costs for water risks. The most suitable approaches were selected for the purpose of this study and used for the Company water risk assessment. In the previous chapter the Company water related risks were identified using publicly available data and personal interviews. In this chapter chosen water risk assessment tools will be used to examine the Company.

4.1. Selected tools implementation

4.1.1. Aqueduct Water Risk Atlas

The Aqueduct Water Risk Atlas [14] was developed in 2013 by Water Resource Institute[15]. The tool is at no cost, publicly available global database to provide users with present and future projected water related risks. The Aqueduct specify three risk categories with followed indicators:

- Physical Risks Quantity: Baseline Water Stress, Baseline Water Depletion, Groundwater Table Decline, Interannual Variability, Seasonal Variability, Drought Risk, Riverine Flood Risk, Coastal Flood Risk
- Physical Risks Quality: Untreated Collected Wastewater, Coastal Eutrophication Potential
- Regulatory and Reputational Risks: Unimproved/no drinking water, Unimproved/no sanitation, Peak RepRisk country ESG risk index

These indicators are applied to the global map and show the risk rating in 1-5 scale. There is a possibility to get annual overview for all indicators and monthly for just three of them (Baseline Water Stress, Baseline Water Depletion, Interannual Variability). In addition, the tool includes three scenarios for future water availability based on the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report: “optimistic”, “business-as-usual” and “pessimistic” scenarios in 2020, 2030 and 2040. The water risk indicators have different weightings for nine business sectors: Agriculture, Food & Beverage, Chemicals, Electric power, Semiconductor, Oil & Gas, Mining, Construction materials and Textile. In case of the Company (i.e., Agricultural sector) Water Quantity Risk has the highest weight – 69%, followed by Water quality and Regulatory and Reputational risks – 17% and 14%, respectively.

Regarding the required input data, the user just need to point or enter an address of the location of the business on the global map and press “Apply analysis”. As result a short

[14] https://wri.org/applications/aqueduct/water-risk-atlas
[15] https://www.wri.org/

table with a summary of the location will appear in addition to the Overall Water Risk rating. The user can customize the results by choosing which indicators from the proposed list he wants to show on the map. The analysed data can be downloaded as a CSV file for further analyse in Excel or as a ZIP file for QGIS or ArcMap. There are no other options to show the analysis. This makes the tool useful as a basic, base line assessment of water risks in the given location. Worth to mention, that the tool often used as an input data provider for other tools (e.g., Water Risk Monetizer, Water Risk Valuation Tool by Bloomberg etc.).

The Company assessment through the Aqueduct tool shows "Extremely High (4-5)" Overall Water Risk. When the user lists down the results from each indicator separately, the Company´s location got following results presented in the table below (Table 6).

Table 6. The results of the Company´s assessment in the Aqueduct tool (due to 01.09.2019)

Water Risk Indicator	Rating
Physical Risks Quantity	Extremely high
Baseline Water Stress	Extremely high
Baseline Water Depletion	Medium high
Groundwater Table Decline	No data
Interannual Variability	Medium high
Seasonal Variability	Medium high
Drought Risk	Medium high
Riverine Flood Risk	Extremely high
Coastal Flood Risk	Low
Physical Risks Quality	Low
Untreated Collected Wastewater	Low medium
Coastal Eutrophication Potential	Low medium
Regulatory and Reputational Risks	Extremely high
Unimproved/no drinking water	Extremely high
Unimproved/no sanitation	Extremely high
Peak RepRisk country ESG risk index	Medium high

The projected changes for 2030 and 2040 are very general and do not differentiate among the calculated years or scenarios (Table 7).

Table 7. Projected change in four indicators from baseline (1950-2010 average) to 2030 and 2040 in tree scenarios due to the Aqueduct tool (due to 01.09.2019)

Indicators	2030			2040		
	Pessimistic	Business as usual	Optimistic	Pessimistic	Business as usual	Optimistic
Water Stress	1.4x decrease	1.4x decrease	1.4x decrease	1.4x decrease	1.4x decrease	1.4x decrease
Seasonal Variability	Near normal	Near normal	Near normal	Near normal	Near normal	Near normal
Water Supply	1.4x increase	1.4x increase	1.4x increase	1.7x or greater increase	1.7x or greater increase	1.4x increase
Water Demand	Near normal	1.2x decrease	1.2x decrease	Near normal	Near normal	Near normal

To conclude, the results from the Aqueduct Water Risk Atlas provide with a very general overview of water risks the Company could face. These are not sufficient for the decision-making process but could serve as a starting point of a water related risks assessment.

4.1.2. Water Risk Filter

The Water Risk Filter (WRF)[16] was developed in 2012 by the World Wildlife Fund (WWF) and Deutsche Investitions- und Entwicklungsgesellschaft (DEG). The spatial reach of the WRF is global. The tool is assessing water related risks via basin and company perspective. Basin risks are checked by using 32 different maps and country level peer-reviewed data sets. The result could be shown directly after pointing company´s location. For the business operations´ water risks examination the user should fill out the questionnaire and provide the company´s specific water related information. The WRF has a division for physical, regulatory and reputational risks. Each of this risk types is divided for risk categories which have their own risk indicators (WRF 2019).

After providing the site location and answering the site-specific questionnaire, the WRF creates a risk chart which aggregated risk scores (from 1 to 5) for the basin and the site´s operations. The user can download the results as a PDF or EXCEL file. In addition, the tool has a "Respond" section which provides a customized set of response actions with mitigation options for the Company. The recommendations are based on the risk assessment and contain references to the sections in commonly used guidelines for water good practices: Alliance for Water Stewardship, Ceres Aqua Gauge, CDP Water, CEO Water Mandate and SDG 6.

In the case of the Company the Water Risk Filter assessment shows total operational and basin risk as 3.6 and 3.7 respectively (Figure 14). The highest risks are in the physical risk category – 4.2 out of 5.0. The reputational and regulatory are nearly the same – 2.4 and 2.0 respectively.

The detailed Basin Risks assessment is generated automatically based on GPS position. Regarding the physical water related risks, the Company is located in the arid region, the water depletion is significant (Seasonal depletion; for one month of the year on average, the monthly depletion ratio is >75%). Baseline water stress is very high >80% according to global dataset and very high >80% according to FAO water stress. In 2015 - 2018 the estimated occurrence of droughts is extreme high. In the same time, the estimated occurrence of floods is high (31–400 floods occurred between 1985 to 2019). The surface water contamination (including nitrogen, phosphorus loading and pesticide) is moderate. Ecosystem services have some risks: freshwater has very limited impact on biodiversity.

[16] https://waterriskfilter.panda.org/

In respect to regulatory water related risks, the national Freshwater Policy Status (SDG 6.5.1) has a moderate status of implementation: >30 to <=50 / or no data. The Freshwater Law and Implementation of Water Management statuses are on the same level as policy. Corruption Perceptions Index of Peru is very high 20-39 (where 0 is the highest and 100 is the lowest corruption rank). According to the global dataset, Peru is free country with partly free press 2.5 (1=most free, 7=least free). The country has a moderate status of business participation in water management: >30 to <=50 / or no data. Groundwater has moderate monitoring density. There is a very low monitoring density of runoff (up to 1 station per 1000 km^2 of main river system). At the same time 90-95% of the population have access to safe drinking water, and 60-80% to improved sanitation. The country has a low level of financing for water resource development and management: >10 to <=30.

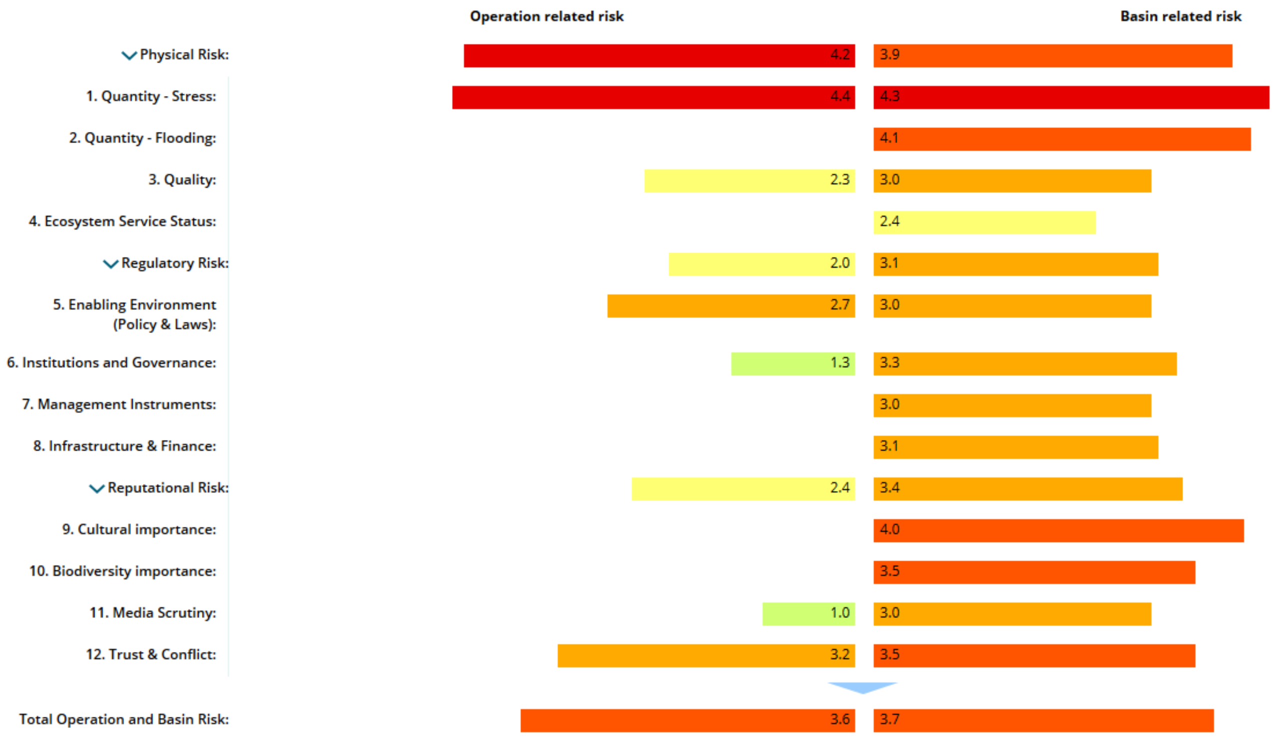


Figure 14. Risk chart for the Company produced by the Water Risk Filter (accessed on 01.09.2019)

The reputational water risks basin assessment shows that, water is considered somewhat important by the local culture and/or religion. The number of ethnolinguistic groups is: >50 and <=100. There is very high risk of freshwater endemism (>25 endemic fish species). Freshwater biodiversity has limited risk, 21-40 freshwater fish species are present. The awareness of local residents about water issues in this specific river basin is moderate (occasionally >1 per 6 months) which includes the status of the river basin (scarcity, pollution), as well as the importance of water relative to other aspects in life of the local people (like food and shelter security). The awareness outside the basin is also moderate (occasionally >1 per 6 months).

The detailed Operation Risks related indicators are based on the questionnaire and show that, the Company has very high physical risks, due to following factors: The majority of the water used is added into the product, with some water used for processing, cleaning or domestic purposes (drinking water & sanitation). The water quantity and/ or quality is critical (vital) for this site. The site had problems withdrawing the required amount of water for its operations or has the site experienced a significant flooding event affecting operations. The total annual amount of freshwater withdrawn (directly from any water source including municipal supply utilities) is >10,000,000 m^3/year. The total annual amount of freshwater discharged from this site to any endpoint (including municipal wastewater utilities) is 1,000,000-10,000,000 m^3/year. The primary source of electrical energy is hydropower (from the national grid). From all discharged freshwater 0% contains contaminants and is discharged directly to the environment (not to another entity such as on-/ off-site water treatment plants). Very simple filtering is required for the fresh water that the site withdraws before its use in operations. Some filtering and biological treatment is required (no chemical cleaning, e.g., to reach discharge water standards) for the water that site withdraws after its use in operations. In addition, large volumes of low toxicity chemicals used in the site or stored on site or minimal volumes of high toxicity chemicals used or stored in the site. The site´s operations have limited effect on downstream water quality on downstream water quality in terms of physical, chemical and biological parameters. The site is under similar regulation and/or legal enforcement (related to water) relatively to other water users in local catchment (~ 50 km radius). Changes in water price or quality standards are being discussed.

Regulatory water related risks are on medium level. The Company meets all existing quality standards and has either a company standard and/or has a compliance system in place. This site has not been subject to any fines, enforcement orders, and/ or other penalties for water-related regulatory violations in the last year. Strong, accessible platform exists in which the site is actively engaged, and stakeholders come together to discuss water-related issues of the basin. No negative coverage of the issues or the site in local/ national media coverage, and no negative global media coverage of the issues, the site or the company (positive coverage acceptable) on a water issue in the past 5 years.

Regarding reputational water related risks WRF shows that, relative to other water users in local catchment (~50 km radius) the site uses relatively larger amounts of water/pollutes but would not consider it high. Furthermore, relative to other water users in local catchment (~50 km radius) the site is a recognizable brand to most/ all locals. The Company has long-standing, advanced water stewardship practices. The Company was not involved in any water related disputes with other stakeholders in the basin within the last 5 years.

The “Respond” sections showed the distribution of recommended response actions, spread across 10 categories, for the Company based on its water risk assessment results and water stewardship maturity level (Figure 15). The graph could be expanded and shows all the recommendation actions in a list table with a detailed description of each action (Table 8).

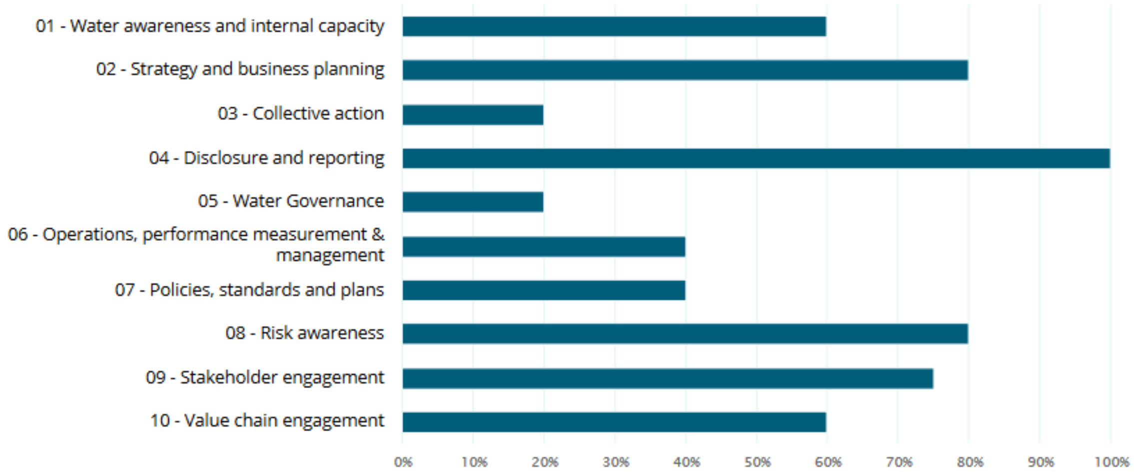


Figure 15. Prioritised recommended responses actions created by WRF based on the Company´s specific information (accessed on 01.09.2019)

The table and recommendations are generated automatically; therefore, all actions are general and depend on answers in WRF questionnaire. Some of actions already could be implemented by the Company. The list could be used as a baseline for the development of a company specific action plan.

Table 8. Ranked list of recommended response actions for the Company based on their water risk assessment results (accessed on 01.09.2019)

Ranked priority	Response category	Action description
1	06 - Operations, performance measurement & management	Gather more detailed water-related data for the catchment that impacts site operations (e.g., Source Vulnerability Assessment)
2	08 - Risk awareness	Perform a more detailed water risk assessment for the site to quantify and prioritize water-related risks that includes detailed operational risks
3	08 - Risk awareness	Support performing a more detailed water risk assessment for the site to quantify and prioritize water-related risks that includes detailed operational risks
4	04 - Disclosure and reporting	Publicly disclose the site's water-related performance against set targets using established and recognised reporting methodologies.
5	04 - Disclosure and reporting	Publicly disclose the site's efforts to address shared water challenges
6	08 - Risk awareness	Assess the energy risks (including price increases, brownouts, blackouts, etc.) to the site of shared water challenges in the region (consider the water risks facing the regional energy grid)
7	04 - Disclosure and reporting	Publicly disclose water-related performance against set targets using established and recognised reporting methodologies via Annual Financial or Sustainability Report
8	04 - Disclosure and reporting	Publicly disclose efforts to address shared water challenges via Annual Financial or Sustainability Report
9	09 - Stakeholder engagement	Engage via direct intervention or via policy on water-related issues affecting (or of concern to) customers
10	09 - Stakeholder engagement	Consult and engage stakeholders, NGOs and community groups on water-related performance

11	10 - Value chain engagement	Substitute environmentally damaging (water-related) products or raw materials for alternatives that minimize impacts on freshwater ecosystems
12	01 - Water awareness and internal capacity	Understand the role of water regulation issues and pricing/tariffs and how they can result in risk to the company
13	10 - Value chain engagement	Request reduced water use throughout the site's supply chain and outsourced water-related service providers
14	04 - Disclosure and reporting	Profile water stewardship efforts and performance in the organization's annual report
15	02 - Strategy and business planning	Make water an included part of the overall corporate strategy (revenue, expenses, assets and liabilities)
16	02 - Strategy and business planning	Develop and implement contingency plans to respond to supply chain disruptions due to water issues for key inputs for the site
17	07 - Policies, standards and plans	Set performance standards and goals through publicly available water policy/statement that align to the water-related SDGs
18	05 - Water Governance	Join a water-related forum (sectoral or intersectoral) - for example, CEO Water Mandate, AWS, WBCSD, ICMM (mining), SAC (apparel), BIER (beverage), etc.
19	08 - Risk awareness	Create or increase corporate management's or board's awareness of relevant business water risks and shared challenges in corporate sustainability, procurement and operations
20	03 - Collective action	Engage with peer companies in regionally specific water-related benchmarking
21	10 - Value chain engagement	Request reduced water use throughout the site's supply chain and outsourced water-related service providers
22	01 - Water awareness and internal capacity	Engage in raising water awareness of potential customers by providing information through various media channels and/or cause marketing
23	02 - Strategy and business planning	Calculate how water can affect the site's financial value and integrate into decision-making related to opportunity identification
24	07 - Policies, standards and plans	Develop a formal plan for climate change adaptation
25	01 - Water awareness and internal capacity	Review (or conduct) a formal study on future water resources scenarios including water supply and quality resulting from higher demands within the basin and how it may affect the company's operations and value chain.
26	09 - Stakeholder engagement	Identify stakeholders, their water-related challenges and the site's sphere of influence
27	06 - Operations, performance measurement & management	Maintain or improve site water balance / achieve sustainability performance levels outlined in context-based water targets
28	02 - Strategy and business planning	Understand the Human Right to water and particularly the potential implications to the company's business

To summarise, the Water Risk Filter allows to identify water related risk at site, company or portfolio level. The user of the tool is required to provide not only a company´s location but also the operation specific information. With that data the WRF provides a rating for overall, physical, regulatory and reputational risks. The "Respond" section helps the user to prioritise and to decide for the response action. In overall, the Water Risk Filter has a more advanced and comprehensive risk assessment then the Aqueduct tool. The WRF is partly using the information provided by the Aqueduct Water Risk Atlas. The WRF is more specific to a company´s operation. However, up to now, the tool does not allow the user to calculate the cost of water related risk or put a monetary value to the water. The Water Risk Filter can be used as an identifying mechanism for water related risks and helps to identify mitigation actions for each site/ company.

4.1.3. Water Risk Monetiser

The Water Risk Monetiser (WRM)[17] was developed in 2014 by Ecolab in a partnership with Trucost and Microsoft. WRM is s free publicly available global water risk assessment tool. WRM recognises physical, regulatory and reputational water related risks. In addition, it recognises also financial water related risks, which includes "Increased financing costs and reduced financing options as market participants demand more transparency on corporate water risk" (ECOLAB 2017). The tool requires the user to provide business specific information on water use, water prices and production data. The WRM calculates incoming and outcoming water risks, which may result in increased operating costs. It takes into consideration the water availability, quantity and user competition on water resources (in the region) on basin level across a three-, five- and ten-years' time horizon.

Regarding the input data, the user is asked to provide the location of the site, water use and discharge amount along with water prices. If the business location is currently experienced droughts or the user would like to understand a company´s risks related to water scarcity, the WRM has special "drought scenario". In the tool the projected change for the water amount and price of ongoing and outgoing water are mentioned together with the total facility revenue per year and the projected change for next three years. In respect of regulation and reputation water related risks, just five ("yes" or "no") questions are asked. In addition, four question to specify water quality risks and six pollutant specific measures could be provided by the user, otherwise the tool will use pre-set statistical data for country.

The result of some example calculation of the water risks for the Company were done with and without "drought scenario". Both example calculations are included in Annex 7.4 of this study. The monetary estimation of the full example value of water to the Company shows that outgoing water is responsible for 54% of the risks and incoming water for the remaining 46% (Figure 16).

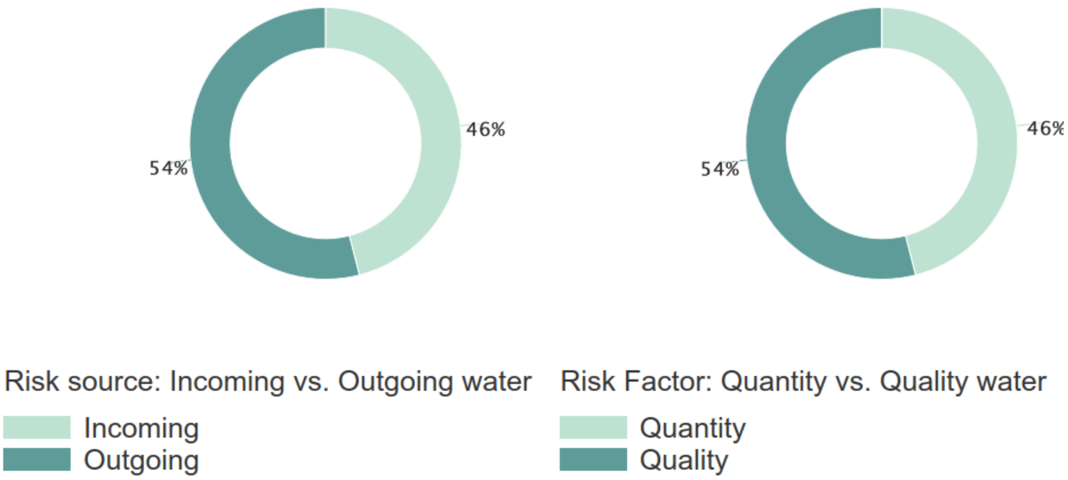


Figure 16.The sum of the incoming risk premium (based on quantity and quality) and the outgoing risk premium (based on quality risk) for the Company by WRM (accessed on 22.09.2019)

[17] https://tool.waterriskmonetizer.com/

For the both scenarios, Incoming Risk Likelihood Score as well as Outgoing Risk Likelihood Score are on a high level. The first score represents a monetary value of local environment, human health and domestic supply impacts of water depletion and the future costs of incoming water treatment. The second score places a monetary value on the local environmental and human health impacts of water pollution and the future costs of water treatment. The difference is the result of the third score – the Revenue Risk Likelihood Score. This score estimates the relation between the business´ water demand and its generating revenue (m^3 per USD of revenue) to the business' share of all available in the water basin. During the "normal" scenario the score is low for the Company. But within the "drought" scenario more water is required than the basin share of water allocated, and a proportion of the Company's revenue is potentially at high risk because of the lack of water for irrigation purposes.

The Water Risk Monetizer calculated Incoming and Outgoing Risk Adjusted Prices for the Company. The results show an extremely high price for the Incoming Risk Adjusted Price in the "drought" scenario – USD 934.79 per m^3, which results into Quantity Risk of USD 12,292,387,840.00 and into Quality Risk of USD 31,188,514.00 per first year. The figures are smaller for the "normal" case scenario but still very elevated: USD 26,834,450.00 and 31,188,514.00 for Quantity and Quality Risks respectively (Table 9).

Table 9. Summarise table with results from WRM calculation of the Company´s water risks (accessed on 22.09.2019)

	Drought Scenario	Normal Scenario
Revenue at Risk	100%	1%
Incoming Risk Adjusted Price (USD per m^3)	$934.79	$2.04
Outcoming Risk Adjusted Price (USD per m^3)	$31.19	$31.19
Incoming Risk Likelihood Score	High	High
Quantity Risk (USD per year)	*$12,292,387,840*	*$26,702,950*
Water Bill (USD per year)	*$131,500*	*$131,500*
Combined	$12,292,519,936	$26,834,450
Outgoing Risk Likelihood Score	High	High
Quality Risk (USD per year)	*$31,168,514*	*$31,168,514*
Water Bill (USD per year)	*$20,000*	*$20,000*
Combined	$31,188,514	$31,188,514
Revenue at Risk (USD per USD)	1.00	0.00

The WRM claim that the obtained results could be helpful for decision makers to identify which site is more affected by water related risks and which investments should be done. From the first look at the water risk costs calculated by the tool, it is difficult to identify which costs are related to which risk type (physical, reputational or regulatory). This is hidden in the special locally calculated indexes, which are part of the final water price projection. The developers used the shadow price approach to attach a value to the water resources in the region. These estimations are making the tool´s results very general and highly dependent on the data source update and accuracy. In addition, the WRM includes also an estimation of the basin share of water available within a water basin for business use according to the amount of economic activity within the same water basin. However, the research of this study shows that the data record is not very reliable in the studied basin and changes of the business actors are frequent.

The tool could be used as a second step of costs of water risk calculation, but not for identifying water risks. The Water Risk Monetizer estimated a full monetary value for the Company, based on what water would cost if supply and demand were accurately priced. It also calculates potential revenue at risk of increased operating costs due to the impact of water scarcity or quality on operations. But all estimations are calculated via the shadow price method and this brings some uncertainly to the results. First of all water prices which are included in the calculation are very low and not representing the real water resource situation (see section 3.3.3.). Secondly all the other data for the evaluation of reputation and regulation are very general and not on a site-specific level. As a conclusion, the tool could be a good stimulation for giving attention for water savings technics and improving water management in overall. That because multimillion costs of incoming or outgoing water related risks would make decision-makers aware of the financial implications of the water risks. The Water Risk Monetizer could be used as good support for better trade-offs between different water investments and measuring the consequences in general terms.

4.2. Conclusion

The assessment of the costs of water related risks for the Company through the chosen three tools show that no one of them on its own is sufficient enough to obtain comprehensive results. Each of the tools have their strengths and weaknesses. A more complete analyses could be obtained by using all three tools together. Nevertheless, the results tent to be general, even though the Company´s specific information might have been provided. The Aqueduct Water Risk Atlas is a tool for which nearly one third of all reviewed tools are referring as a data source. But the screening of the Company´s data in the Aqueduct resulted in general identification of water risks in the region, no specific estimation could be achieved as a result. The Water Risk Filter provided more comprehensive water risk analyse and a more site personalised (via questionnaire) results. The tool not only provides site-specific water risks, but also gives recommendations (with references for guidelines) for response actions. However, the Water Risk Filter does not provide monetary valuation of determined water related risks in the moment, just a simple “traffic light” rating from 1 to 5 for support decision-makers. The Water Risk Monetizer is at the moment the only one from these three tools, which is actually monetarising the value of the water risks. The weaknesses of the WRM is in the identification of the water risks, it can just determine which ingoing or outgoing water is under higher risk. Despite that, the tool estimates the adjusted water price (i.e., true price) for the Company in normal and drought scenarios. The figures are high for both sequences, but drought water cost is rising to billions. Such estimations are hardly to be realistic, even in strong drought scenario. The maximum losses could be for example, the total loss of production, which are not billions in the Company case. The calculations are based on the shadow prices approach and this brings uncertainty and generalisation for the estimation. High costs in the WRM could be a driver for an establishment or improvement of existing water resource management in the Company. The tool is good in the identification of sites or companies at higher risk then others in a portfolio. For the Company (as an only one for calculation) the result shows how much water could cost based on the tool´s developers created indicators.

To conclude, the tools are better to be used together for more comprehensive analysis. However, the summary reports from all of them should be reviewed and personalised for the individual business case. Even all three together can be used as a first assessment. For the specific and more meaningful analysis, a business still has to combine several tools in a combination with the company´s insides and elaborate additional calculations with the internal financial figures.

5. COSTS OF WATER RISKS

In this chapter, the costs of water related risks will be calculated for the studied Company using author´s proposed methods. Each business is individual in its operations details (e.g., technologies, technics) and basin conditions. Even though, some companies could be aggregated in one sector of production, local environment or government are bringing differences to each risk assessment. During the course of this study it was learned, that available tools could provide just a simple overview of possible water related risks and calculate their costs in a very general way. Consequently, this chapter will propose a more specific water related costs calculation for the studied Company using available data and figures.

5.1. Parameters to be used and methodology

Initially, modified and adopted financial statements and balance sheets were going to be used for water related risk calculation. However, it was noticed that water related costs are not separately reflected in the figures of any sheets of the Company. On the one hand, they are part of operational costs, extraordinary losses and others. It is extremely important to have a detailed accounting for water related expenses for the purpose of the risk evaluation. On the other hand, during the El Nino years many producers are facing yields losses and the production of crops (e.g., avocado) is reduced and cannot cover all market demand. The market reacts with higher prices in such years (Figure 17). The Company, as many others agricultural producers, sold in 2017 less crops as was planned, but because of the higher market prices their revenue from the selling was in the same line as projected. It is worth to mention that in 2018 avocado form Peru covered the biggest part of EU avocado-market

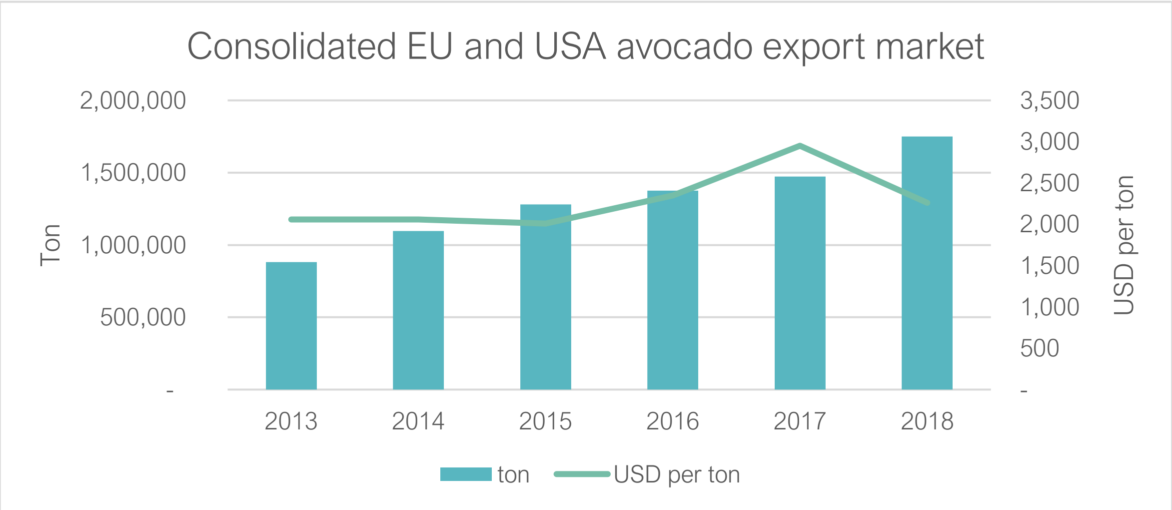


Figure 17. Consolidated EU and USA avocado export amount and prices during 2015 – 2018 (source: EC[14] and USDA[15])

demand (export of 38% from the total demand)[18] and second big part for USA (export covered

[18] https://madb.europa.eu/madb/statistical_form.htm

8%, after 88% from Mexico)[19]. The opposite situation was observed in 2018. The weather and climate conditions were very good for agriculture, so farmers collected more yields than planned. As the market was full of crops (e.g., avocado, asparagus) the prices were low. In that case, the Company achieved their selling revenue because of a larger amount of crops sold. Hence, financial statements and balance sheets do not reflect really the costs of water linked risks.

Therefore costs of water related risks in this study is calculated as a sum of individual costs payed by the Company to avoid (i.e., prevent), to mitigate the risk or to deal with consequences (i.e., when no action is undertaken). These three “scenarios” were chosen to represent the most common behaviour of every business towards risks. Firstly, if the Company was not taking any actions against water related risks, it faced infrastructure and field damages, yield losses and other consequences which have an impact on revenue and appear as costs to be paid for known or unknown water related risks. Secondly, the mitigation expenses are paid by the Company in order to reduce the costs of known risks. Some of the risks (e.g., floods, mudslides) are almost impossible to avoid, so the only chance to lighten the impact on the business is to undertake some mitigation actions. Thirdly, the avoiding actions are one of the most expensive for the business. They usually include high investments and require more time for implementation. However, the “avoidance” costs cannot be compared directly to the “no action” or the “mitigation” costs, because the benefits of these high investments (e.g., change of an irrigation technology) will appear not only in risks avoiding but will have a positive influence on the business at all (e.g., productivity, sustainability, etc.). So, the comparison of these three “scenarios” is not suitable on this level of examination but requires deeper study of the investment-consequences relationship and influence.

It is important to keep in mind that all costs are differently allocated in the timeline. This is another obstacle on the way to simple calculation of water risks costs. As mentioned before, some costs can have long time effect, and some brings benefits directly after paying. In this work for simplifying purposes, costs are differentiated between yearly costs (i.e., should be paid more than ones) and one-time costs (e.g., investments, reconstructions expenses, yield losses).

Within this study, the list of potential water related risks was collected (see Chapter 3). Based on these risks the calculation will be presented. The assessment includes the maximum of past, present and future-potential costs which were or could be undertaken by the Company. For the calculation 2017 was taken as example because of the high expenses due to El Nino impact. The costs are calculated according to the provided data (if available) and assumed approximation (base on internet research). During this study, it was learned that the Company has to collect - data yearly and prepare all water related figures regularly in order to determine the costs of water related risks. This requires big efforts and statistical work from the Company. Such measures were not undertaken by the Company. Taking in account this, the qualitative assessment (Red, Orange, Yellow rating) of costs of water related risks is presented in this study in addition to cost calculation of available Company´s data.

[19] https://www.ers.usda.gov/data-products.aspx

5.2. Costs calculation

Below is described cost calculation logic for each of the Company´s water related risks. Since all risks are linked together and their consequences are interconnected, in this calculation the risk will be mentioned only under one risk type, which has the highest impact on author´s opinion. Assembled tables with available figures (Table 13) and cost colour-rating (Table 14) are presented in annexes.

5.2.1. Physical water risks costs

Participating jointly with the Commission of Irrigation from the Chavimochic Special Project in the maintenance the drains network area is preventing uncontrolled rise of the groundwater level. The cost could be expressed as an amount dedicated from the annual budget. However, this has also a long-term benefit not only of avoiding high groundwater level and soil degradation but also increasing soil productivity and yields. It is important to collaborate with other stakeholders, because it reduces the costs payed by each actor.

Groundwater control sensors in wells are used for the observation of the groundwater level. This equipment helps the Company ensure sustainable groundwater management and avoid overexploitation. Moreover, it could signal when the level is too high, and water should be pumped in order to prevent field flooding. The cost could be calculated as a price of installation and maintenance of one sensor multiplied by number of wells in the Company. Otherwise, the mitigation could be calculated as a cost of flooded fields and soil degradation.

The Company was not exposed to long water shortages periods during the study period. There was just limitation in the water flow for a few days due to damages of the main irrigation channel as a result of a mudslide. To secure the water supply for a short period (e.g., one week) the Company constructed water reservoirs. This mitigation action could be calculated as expenses for the construction and maintenance of reservoirs.

Drip irrigation technologies is used by the Company for the crop irrigation and fertilisation. It helps the Company to reduce significantly the water usage compared to surface or sprinkler irrigation. It allows 90% of water to be used by crops and just 10% is evaporated. However, there are more sophisticated techniques which could help to use water resource more efficiently and reduce the amount of water used. One of those is the subsurface drip irrigation technique (Martínez and Reca 2014). Especially suitable for arid and semi-arid areas with limited water supply and with sandy soil types. In addition, a hygroscopic moisturizer could be used for stronger effect. The implementation of subsurface irrigation and hygroscopic moisturizers techniques could save up to 10% and 30% of water, respectively. Consequently, these technics are sophisticated and require expensive equipment and maintenance. The advantages are water and fertilizers reduction and labour savings due to high level of automation. Besides this high investment could help the Company reduce risks during water shortages periods and can increase crop productivity. The cost of the subsurface irrigation installation costs is around EUR 450 per hectare (Netafim[20]). Hygroscopic moisturizers application requires around 10 litres per hectare, EUR 90 per application of one hectare and 3 applications per year (Water & Soil[21]). The simple cost calculation could (without long-term additional benefits) be performed as next:

$$Cost = prise\ of\ instalation\ per\ ha \times total\ amount\ of\ ha \times application\ per\ year$$

Also the reduction of water and fertilizers consumption should be included in the calculation to assess possible advantages of proposed irrigation methods compared to today used technology (i.e., surface drip irrigation). In addition, the lower water consumption for irrigation will result in reducing filtration to groundwater and thus stabilise the level of the groundwater table. This will help to avoid field flooding, soil degradation and might be used as an adaptation to the next level of water scarcities in the region, but these benefits have to be calculated separately.

$$Savings = (Total\ water_{usage} \times water\ tariff \times price_{\ fertilizers\ per\ m^3}) \times \%_{\ water\ reduction}$$

The ENSO related damages and costs are one of the highest of water related physical risks for the Company. During last El Nino event in 2017, the Company had estimated losses for about EUR 13.4 million. The main impact was done by mud slides. Avocado and asparagus fields (~350 ha) were affected which resulted in EUR 5.1 million losses in assets. However just 5 ha were covered by mud slides, this resulted in disconnecting irrigation system for the rest of 345 ha of fields. Losses of 1,500 tons of asparagus and 700 tons of avocado yields reduced gross margin for EUR 0.7 million and EUR 0.8 million respectively. In addition, the main irrigation channel of the Chavimochic Special project was destroyed which left the fields without water supply for 15 days. The Company was not able to apply pesticides and fertilizers to crops during most of that time (for 7 days the Company was using water from backup reservoir). This long water stress impacted the quality of fresh avocado, asparagus and artichoke production and resulted in estimated EUR 6.8 million losses. The effect of El Nino for the Company´s supply chain and contractors also were high. Due to heavy rains in the northern parts of Peru, contracted farmers had delays and reduced planting hectares of peppers. This resulted in estimated EUR 1.7 million losses for the Company. The figures were presented for 2017 and will be different for other years, depending on the Company operation and preparedness for the phenomena. Even though it was not the first El Nino in the Company operation history (previous strong one was in 1998), costs for the Company were high.

On the one hand, it is impossible to avoid the phenomena of El Nino, but on the other hand it is possible to mitigate the impact. The Company has an insurance for plants, offices and storage buildings in case of floods (there is no insurance for the fields or yields in Peru). As of 2019, the Company started to build fence using sandbags for the reservoirs, buildings and wells in order to protect them from possible flood events. This is a mitigation action which also require expenses. Moreover the Company ensured 3 months storage of diesel, fertilisers and pesticides in case of supply shortages.

[20] https://www.netafim.com
[21] https://www.waterandsoil.eu

The losses in 2017 could have been higher, but the Company avoided them due to diversification of crops (e.g., asparagus, avocado, artichoke, peppers), fields location (north and south of Peru), product lines (e.g., fresh, frozen, preserved) and selling markets (e.g., Europe, USA, China). These helped the Company to maximize sales and mitigate El Nino related losses. Firstly, different crops have different water requirements, for instance, asparagus is more resistant to water shortages than avocado, so potential yield losses might be lower. Secondly, having fields in locations which are not so much exposed to El Nino effects helps reducing the risks. Thirdly, if the yield is partly harmed and some fruits cannot be sold as fresh (due to shape, colour etc.) they could be used in canned production. Last but not least, diversification in markets helps the Company to get better and more competitive prices as well as sell its products in a time of harvest delays.

Another opportunity to reduce the impact of El Nino and followed extreme floods could be seen in the Payment for Ecosystem services approach. The Company with joint efforts from government and other agricultural companies could establish a program for paying farmers in the upper basin for growing flood protection forests. Mature trees will capture some amount of water during rainy seasons and prevent huge floods and mudslides in the lower basin. This action could be beneficial not only for the agriculture but for all population and other stakeholders affected by floods and mudslides damages.

5.2.2. Regulatory water risks costs

The regulatory water related risks could be calculated as costs of fines paid for breaking national or local water regulations. In the Company case, it was obliged to treat its industrial effluents to the national standard level. As a result, the construction of the wastewater treatment plant was a price to pay to avoid annual fine payments or production shutdown. Constructing the WWTP requested a significant amount of financial investment and time for investigation for the best technology. Moreover, it is an additional stimulation for reducing the amount of effluents and as a result more efficient water use and decrease consumption. This also gave a possibility of reusing about 1 MCM of treated water for irrigation purposes. However, now the Company has to control their own effluents even more effectively, because the maintenance of the plant is a part of annual expenses. On the other hand, without WWTP the Company has to pre-treat its wastewater and discharge it to municipal or private treatment facility which would also implicate additional costs.

National or local poor water management resulted in uncertain risks for the Company. Today it results in difficulties for obtaining the water permits approval by the authorities. This could be calculated as costs of salaries of people who has to work on getting them. Withdrawing water without license would require paying a fine or even would result in stopping operation. Concerns and protests from the small and medium size farmers could result in water regulation changes. It is difficult to measure such risks, but the extreme scenario could be dramatical. To mitigate this risk, it is recommended that the Company has to be active in stakeholders´ engagement of all water users in the basin as this will help to identify the disagreements and concerns early enough.

Weak regional water authority or absence of a catchment council could lead to water mismanagement practices in the basin by different water users. This creates a mistrust between actors and creates an uncertain future for the Company water resources supply. This risk is critical but hard to monetarise. A mitigation could be joint efforts of agricultural businesses in the basins and creating a River User Board or an Irrigation Commission of Chavimochic Special Project. Just collective collaboration and willingness to establish sustainable management can avoid regulatory chaos. If one company will have the best state-of-art technologies and comply with all regulations, it will not save the business from the reputational risks their neighbours may create, who might break all rules and misuse water resources.

5.2.3. Reputational water risks costs

The Integrated Pest Management practice obligated the Company to buy pesticides with a lower environmental and health impact and minimising the chemical control of the plantations. The price of such pesticides is higher, but it brings several benefits. The potential pollution of the groundwater is reduced, it has a positive impact on local biodiversity (e.g., birds' population) and secures a good reputation for the Company in local communities. The cost could be calculated as:

$$Cost = price\ of\ kg\ of\ pesticide \times amount\ of\ kg_{per\ ha} \times total\ amount\ of\ ha$$

On the other hand, the Company could continue to use traditional pesticides. As a result, there would be a higher for the groundwater pollution, community concerns and government sanctions might take place. In addition, it could lead to losing customers on international markets, who have high standards for environmental and social impact of their suppliers. This is not the case of the studied Company but could be assumed with simple estimation like costs of fines, social payments for communities, or decrease of sales.

Annual reporting regarding the water management practices and other environmental matters is an important communication element for avoidance of reputational water related risks. The costs might be calculated as working hours of personnel for preparing such document. Otherwise, if the community has a limited information or concerns about the Company´s impact on water resources or fertilizers practices, strikes or protest might occur. These risks could be shown as losses due to lower productivity, delays or even could lead to closing of the business. The positive effect of open and regular disclosure could not be neglected.

Community support after El Nino damages is a part of the Company´s social programme. It includes drinking water supply in periods of shortages, purchase of construction material for house restorations, providing clothes and first aids to neighbouring communities. These all expenses could be sum-up and result a total cost for maintain high social responsibility reputation among the local population and the Company´s employees.

5.3. Calculations conclusion

Financial statements and balance sheets cannot clearly reflect water related costs for the enterprises. Hence the financial reporting is not a suitable data base for the analysis. The sum of individual risks costs could be used to assess the Company´s specific water risks expenses. Three possible “scenarios” were proposed to classify the Company´s actions: no actions against risks, mitigations and risks avoidance actions. Costs also were distinguished between one-time and annual payments. The study recognises that there is a difference in the time periods of benefits effects for all actions undertaken by the Company (especially in the “avoid” scenario). Since some investments could be considered not only like risk avoidance measurements but also have influence on the business´ operations (e.g., crop productivity), this beneficial part should be included in future calculations.

As a result of this study, it could be concluded that in order to perform detailed cost calculations of water related risks, the Company has to perform a more through monitoring of water related data. It is recommended that the business should have in place a data collection with present and past statistic for the calculations. However, the studied Company did not have the record of all required expenses. As a result, a rating-based cost estimation was proposed in order to perform a basic cost of water risks analysis. The model could be used for more detailed calculations once the Company have obtained the required figures.

The developed calculation showed the higher costs (in “no action” scenario) for the physical water related risks, especially of the El Nino impact. According to the 2017 data, losses exceeded an estimated EUR 13.6 million (Table 13). Monetarise estimation of regulatory and reputational water related risks is more difficult due to the lack of available data. The colour-rating estimation shows in average higher costs on the “avoid” scenario and lower on the “no action” (Table 14). However, the pure comparison of both costs is inappropriate due to the multi beneficial influences of the “avoidance investments”. In order to analyse the effects of the high costs, it is recommended that the Company should estimate all possible impacts of these investments in long-term and short-term prospective.

6. CONCLUSION

Nowadays the business world is facing higher water risks impacts with every year. The categorisation of water risks was introduced by a collaboration of different international organisations (e.g., The CEO Water Mandate, WWF, Ceres) and business representatives during the last decade. Now it is the most commonly used for water risks interpretation for the corporate world. It identifies three category of water risks:

- Physically risks - having too little water, too much water, poor quality water, or inaccessible water;
- Regulatory risks - changing, ineffective, or poorly implemented public water policy and/or regulations;
- Reputational risks - stakeholder concerns that a company does not conduct business in a sustainable or responsible way with respect to water.

After the determination of water related risks, a business should define the valuation technic to measure the monetary costs of those risks for the business. However, todays´ literature is more concentrated on topics like water valuation, natural accounting, ecosystem services and the measure of the biodiversity. Today (2019) businesses are using many different approaches to report their costs related to water risks. Companies share their findings via disclosure initiatives or harmonised sustainability reporting, but the data is hardly comparable because of the lack of commonly acceptable methodology for cost calculation of water related risks. Often valuation methods are developed inside the firm and are not shared with civil society or other companies. Some of them are not excluding double accounting or other relevant mistakes. Several steps are being done to overcome these problems. Initiatives as the ISO 14008:2019 or the Task Force on Climate-related Financial Disclosures are created to bring standardisation for environmental risks accounting (including water risk). But all reviewed frameworks and guidelines are lacking actually applicable calculation methodologies. Most of them are leaving this detailed work up to the business itself. During the last two decades the corporate world has adopted several commonly acceptable and easy to apply water risk assessment tools. All of them have their strengths and weaknesses and there is room for improvement and for more local specific as well as business personalised results. The result from the review of available tools suggests applying more than one tool, in order to get more comprehensive and detailed results. However, at the end of the day, all results from the tools´ reports should be reviewed and adjusted for the business specific case.

The identification and assessment of water related risks for the case study Company from publicly available datasets faced number of challenges. The difficulties were related to poor data records and statistic on national and local levels. To overcome these problems the Company is required to put great efforts in monitoring of water related data, what leads to an additional expense. Otherwise it makes future projections and management planning (incl. water management) difficult. Despite the poor-data obstacles the current study identified relevant physical, regulatory and reputational water related risks for the Company. The results show that main physical water risks are high groundwater level and El Nino phenomena as an extreme weather event. Uncertainty in future water management on national level together with the poor local water management are the highest regulatory water related risks. Reputational water risks have the lowest level due to the strong social and environmental engagement of the Company within the local community. Additionally, the studied catchment is not facing any water shortages till now, so every water demand for irrigation could be fulfilled. But the concerns are about potential water scarcity in the 15-years future which are already studied among the scientific community. This is mainly due to diminishing of the Andean glaciers in the upper catchment areas.

Three tools were identified as the most adequate for valuating water related risks: the Aqueduct Water Risk Atlas, the Water Risk Filter and the Water Risk Monetizer. The Company was assessed using those selected tools. The results from this assessment shows that, the Aqueduct, WRF and WRM give more comprehensive analyse when the assessments are combined. The final reports from all of them should be reviewed and personalised for the individual business case. For the specific and more meaningful analysis, the Company still has to use several tools in a combination with the Company´s insides and additional, Company specific calculations.

Finally, this study proposed a possible model for evaluating the costs of water risks for the studied Company. The estimation of financial implications is based on previously identified water risks and their related costs during the three scenarios: no action against the risk, mitigation actions and risks avoidance. As a result of this study it was learnt that in order to perform detailed costs calculation of water related risks, the Company has to monitor regularly the water related data. In this way, the business should prepare the figures from the previous years. However, the records of all required expenses of the studied Company were not available. As a result, a rating-based cost estimation was proposed in order to perform basic costs of water risks analysis. The model could be used for more detailed calculations once the Company obtained the required financial data.

The proposed water related costs calculation method shows higher costs for the physical water related risks, especially due to the El Nino impact. To monetarise the regulatory and reputational water related risks is more difficult due to the high level of uncertainty of those events. The rating estimation shows in average higher costs on the “avoid” scenario and lower costs on the “no action” scenario. However, the direct comparison of both costs is inappropriate due to the multi beneficial influences of the “avoidance” investments. In order to analyse the overall effects of the high costs of the “avoidance” investments, the Company should estimate all possible impacts of these investments in the short-term and long-term prospective.

This study confirms that there is no standardisation in the field of calculating the costs of water related risks for businesses. Number of frameworks, guidelines and tools for assessment were developed for the calculation of the costs of water related risks, but there is still a lot of room for improvements and more research should be done on the topic. The standardisation is allowing the comparison and a possibility to learn from others. At the time of high competition for scarce water resources, businesses need this kind of tool to understand better their water risks and relative financial trade-offs. In parallel with standardisation the results should be personalise for a specific company situation. The study also highlights the importance of regular and appropriate data collection on a company level in order to be able to assess water risk related costs for the business. Even the best and most comprehensive methods or tools for calculation are helpless without appropriate and complete data input from a company. The assessment of costs of water risks requires extensive data collection work from a company, standardise methods for calculation and site-specific results.

7. ANNEXES

7.1. List of frameworks, guidelines and methodologies

The following table contains the list of examined in this study frameworks, guidelines and methodologies. It presents:

- By **whom** and **when** an initiative was developed
- The main **topic**
- If it is **water specific** or designed for broader applications (i.e., environment)
- Which **form** an initiative has: Engagement Hub – network organisation, might have own consultations for just members; Guidelines – documents with detailed methodologies; Frameworks - documents with general methodologies; Reports – one time produced
- **Audience** is divided for company level (single facility, whole business, investor), public sector (government) and civil society (incl. Non-Governmental Organisation)
- **Target sector** shows if an initiative could be applied by all business´ sectors or just by specific ones
- **Special purpose** shows if the development was initiated by some case studies or not
- Assessment of the business´s **value** described (assessed) by the initiative in past, present or future period
- **Geography** shows on which spatial an initiative could be applied
- **Access** represents if an initiative is free publicly available
- **URL** – relevant web link (accessed on 01.09.2019)

Table 10. The list of frameworks, guidelines, engagement hubs reviewed for this study

Acronym	Name	Developers		Topic	Water Specific	Form				Audience					Target sector	Special Purpose	Past / Present / Future Value	Geography	Access	URL
		Who	When			Engagement Hub	Methodology / Guidance	Framework	Report	Private sector - facilities	Private sector - companies	Private sector / investor	Public sector	NGOs & Civil Society						
2030WRG	2030 Water Resource Group	World Bank	2008	Water	Yes	X			X			X	X	X	Selected	No	Present / Future	Selected	Free	http://www.2030wrg.org/
A4S	Accounting for Sustainability	HRH The Prince of Wales	2004	Natural Capital	No	X	X			X	X				All	No	Present	Global	Free	http://www.accountingforsustainability.org/cfos/network-of-chief-financial-officers
	AquaWatch	Group on Earth Observations (GEO)	2017	Water	Yes	X				X	X		X	X	All	No	Present	Global	Request	https://www.geoaquawatch.org/
	B Team	Group of business leaders	2013	Business impact	No	X					X	X			All	No	Present / Future	Global	Free	http://www.bteam.org/
BSR EWG	BSR Ecosystem Services Working Group	Social Venture Network	1991	Ecosystem Services	No	X			X		X				All	No	Present / Future	Global	Free	https://www.bsr.org/en/
CNCIG	Cambridge Natural Capital Impact Group	Cambridge Programme for Sustainability Leadership (CPSL)		Natural Capital	No			X			X				All	No	Future	Global	Request	https://www.cisl.cam.ac.uk/business-action/natural-capital/natural-capital-impact-group
	CDP Water	CDP		Business impact	Yes	X	X		X		X	X	X	X	All	No	Present	Global	Free	https://www.cdp.net/en
ESR	Corporate Ecosystem Services Review	WIR	2012	Ecosystem Services	No		X	X	X	X	X	X	X		All	No	Present / Future	Global	Free	https://www.wri.org/publication/corporate-ecosystem-services-review

Acronym	Name	Developers		Topic	Water Specific	Form				Audience					Target sector	Special Purpose	Past / Present / Future Value	Geography	Access	URL
		Who	When			Engagement Hub	Methodology / Guidance	Framework	Report	Private sector - facilities	Private sector - companies	Private sector / investor	Public sector	NGOs & Civil Society						
CNCA	Corporate Natural Capital Account	eftec + pwc	2015	Natural Capital	No			X		X	X	X			All	No	Present	Global	Free	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/516968/ncc-research-cnca-final-report.pdf
B@B	EU Business and Biodiversity platform	European Commission	2007	Biodiversity	No	X			X		X	X			All	No	Present / Future	Global	Free	https://ec.europa.eu/environment/biodiversity/business/index_en.htm
	Global partnership for Business and Biodiversity	Convention on Biological Diversity	2013	Biodiversity	No	X					X	X	X	X	All	No	Future	Global	Free	https://www.cbd.int/
	Global Platform on Business and Biodiversity tools and Mechanisms	Convention on Biological Diversity		Biodiversity	No	X	X	X			X	X			All	No	Present / Future	Global	Free	https://www.cbd.int/business/resources/tools.shtml
	ISO 14008:2019	ISO	2019	Business impact	No			X		X	X		X		All	No	Present	Global	Paid	https://www.iso.org/standard/43243.html
	ISO/FDIS 14007	ISO	2019	Business impact	No			X		X	X		X		All	No	Present	Global	Paid	https://www.iso.org/standard/70139.html
	IUCN's Water Programme	IUCN		Water	Yes	X	X		X		X		X	X	All	No	Past / Present	Global	Free	https://www.iucn.org/theme/water
LfN	Leaders for Nature	IUNC	2005, 2012	Sustainable Business	No	X					X			X	All	No	Future	Selected	free	https://www.iucn.org/asia/countries/india/leaders-nature-india
	LIFE Methodology	LIFE Institute	2015	Business impact	No		X			X	X		X	X	All	No	Present	Global	Free	https://institutolife.org/o-que-fazemos/desenvolvimento-de-metodologias/como-funciona-a-metodologia-life/?lang=en
	Natural Capital Analyzer	Trucost	2016	Natural Capital	No			X	X		X	X			All	No	Present / Future	Global	Free	https://www.trucost.com/publication/growing-business-value-environmentally-challenged-economy/
	Natural Capital Assessments at the National and Sub-national Level	UNEP-WCMC	2016	Natural Capital	No		X			X	X	X	X	X	All	No	Present / Future	Global	Free	https://www.unep-wcmc.org/resources-and-data/natural-capital-assessments-at-the-national-and-sub-national-level
NCC	Natural Capital Coalition	after TEEB	2014	Natural Capital	No	X	X	X	X	X	X	X	X	X	All	No	Present / Future	Global	Free	https://naturalcapitalcoalition.org/
NCFA	Natural Capital Finance Alliance	UNEP FI + Global Canopy	2012	Natural Capital	No	X	X				X	X	X	X	All	No	Present / Future	Global	Free	https://naturalcapital.finance/
NCP	Natural Capital Protocol	WBCSD consortium	2016	Natural Capital	No	X		X		X	X	X	X	X	All	No	Future	Global	Free	https://naturalcapitalcoalition.org/natural-capital-protocol/
NVI	Natural Value Initiative Toolkit	UNEP-FI, Fauna and Flora, the Brazilian business school FGV	2009	Ecosystem Services	No		X	X			X	X	X	X	All	No	Present / Future	Global	Request	http://naturalvalueinitiative.org/
	OECD Water	OECD		Water policy	Yes			X			X	X	X		All	No	Present	Global	Free	https://www.oecd.org/water/

Acronym	Name	Developers		Topic	Water Specific	Form				Audience					Target sector	Special Purpose	Past / Present / Future Value	Geography	Access	URL
		Who	When			Engagement Hub	Methodology / Guidance	Framework	Report	Private sector - facilities	Private sector - companies	Private sector / investor	Public sector	NGOs & Civil Society						
	Oppla	joint activity between the OPERAs and OpenNESS	2016	Natural Capital, Biodiversity	No	X					X		X	X	Selected	Yes	Present / Future	Selected	free	https://oppla.eu
	Oxford Sustainable Finance Programme	the University of Oxford Smith School of Enterprise and the Environment	2012	Sustainable Business	No	X					X	X			All	No	Future	Global	Paid	https://www.smithschool.ox.ac.uk/research/sustainable-finance/
PA-BAT	Protected Areas Benefits Assessment Tool	WWF	2009	Protected areas	No		X						X	X	Protected Area	No	Present / Future	Global	Free	https://wwf.panda.org/?174401/PABAT
	RECon	PepsiCo	2009	Resource efficiency	Yes		X	X	X	X	X				Selected	Yes	Present / Future	Selected	free	https://www.pepsico.com/sustainability/water
	Replenishment programme	Coca Cola	2007	Environmental & Social impact	No			X	X	X	X				Beverage	Yes	Present / Future	Global	Request	https://www.coca-colacompany.com/water-stewardship-replenish-report
SPM	Sustainable Portfolio Management Guide	Solvay	2009	Business impact	No		X			X	X	X			All	No	Present	Global	Free	https://www.solvay.com/en/sustainability/acting-sustainable-business/sustainable-portfolio-management-spm-tool
TCFD	Task Force on Climate-related Financial Disclosures	Michael Bloomberg + Financial Stability Board (FSB)	2016	Business impact	No		X		X	X	X	X			All	No	Future	Global	Free	https://www.fsb-tcfd.org
TEEB	The Economics of Ecosystems and Biodiversity	G8+5 countries	2007	Natural Capital	No		X	X	X		X	X	X		All	No	Present / Future	Global	Free	http://www.teebweb.org
	Total Contribution	the crown estate	2013	Business impact	No		X			X	X	X			All	No	Present	Global	Free	https://www.thecrownestate.co.uk/media/1693/total-contribution-methodolgy-report-2017.pdf
	True Price	Michel Scholte at el	2012	True Price	No		X				X				Selected	Yes	Present	Selected	Paid	https://trueprice.org/
	Value of Water Framework	WWF + IFC	2015	Water	Yes			X	X	X	X	X	X	X	All	No	Present / Future	Global	Free	https://commdev.org/pdf/publications/The-Value-of-Water-Discussion-Draft-Final-August-2015.pdf
	Valuing corporate environmental impacts	pws	2015	Business impact	No		X			X	X	X			All	No	Present	Global	Free	https://www.pwc.co.uk/sustainability-climate-change/assets/pdf/pwc-environmental-valuation-methodologies.pdf

Acronym	Name	Developers		Topic	Water Specific	Form				Audience					Target sector	Special Purpose	Past / Present / Future Value	Geography	Access	URL
		Who	When			Engagement Hub	Methodology / Guidance	Framework	Report	Private sector - facilities	Private sector - companies	Private sector / investor	Public sector	NGOs & Civil Society						
	Valuing Nature Programme	NERC, Defra and the Cambridge Programme for Sustainability Leadership	2014	Natural Capital	No	X							X	X	All	No	Present	Global	Free	https://valuing-nature.net
VWBA	Volumetric water benefit accounting	WIR, LimnoTech, Quantis and Valuing Nature	2019	Water	Yes		X			X	X		X	X	All	No	Present	Global	Free	https://www.wri.org/publication/volumetric-water-benefit-accounting
	Water Action Hub	CEO Water Mandate + Pacific Institute	2012	Water stewardship	Yes	X				X	X		X	X	All	No	Present	Global	Free	https://wateractionhub.org/
	Water Funds Toolbox	The Nature Conservancy		Water	Yes	X		X		X	X	X	X	X	All	No	Present / Future	Global	Free	https://waterfundstoolbox.org/
	Water Risk Valuation Model	Columbia Water Centre		Water	Yes						X	X			Mining	Yes	Present	Global	Request	http://water.columbia.edu/research-themes/risk-and-financial-instruments/water-and-the-mining-industry/
WAVES	Wealth Accounting and the Valuation of Ecosystem Services	World Bank-led global partnership	2010	Natural Capital	No	X	X					X	X	X	All	No	Present	Global	Free	https://www.wavespartnership.org/en
	White Paper: Valuing Water to Drive More Effective Decisions	Yarra Valley Water + Trucost	2013	True Price	Yes		X			X	X				Water industry	Yes	Present	Australia	Paid	https://www.trucost.com/publication/white-paper-valuing-water-drive-effective-decisions/
EBBC	European Business and Biodiversity Campaign	Global Nature Fund (GNF) + IUCN	2010	Biodiversity	No	X	X	X		X					Selected	Yes	Present / Future	Global	Free	https://www.business-biodiversity.eu/en/welcome1

7.2. List of Tools

The following table contains the list of examined in this study tools. It presents:

- Tool´s **name**, **developer** and **year** of the first version
- In which **topic** a tool specialised, if it is **water specific**
- The **form** of the tool (Calculator – has a calculation function; Database (e.g., maps, GIS data); Excel file; Software – a separate program which is required installation)
- **Audience** is divided for a company level (single facility, whole business, investor), public sector (government) and civil society (incl. Non-Governmental Organisation
- **Target sector** shows if an initiative could be applied by all business´ sectors or just by specific ones
- **Special purpose** shows if the development was initiated by some case studies or not
- Assessment of the business´s **value** described (assessed) by the initiative in past, present or future period
- **Geography** shows on which spatial an initiative could be applied
- **Access** represent if an initiative is free publicly available
- The **form of assessment** presented in tool: Qualitative (e.g., colour ranking); Quantitative (e.g., indexes, numeric ranking); Social- Economic – economic value for society; Financial – value for the business
- **URL** – relevant web link (accessed on 01.09.2019)

Table 11. The list of tools reviewed for this study

Acronym	Name	Developers		Topic	Water Specific	Form				Audience					Target sector (being valued)	Cases / Special Purpose	Past / Present / Future Value	Geography	Access	Form of assessment				Online / Offline	URL
		Who	When			Calculator	Database	Excel	Software	Private sector - facilities	Private sector - companies	Private sector - investors	Public sector	NGOs & Civil Society						Qualitative	Quantitative	Social-Economic	Financial		
	Aqua Gauge	Ceres	2011	Water	Yes			X			X	X			All	No	Present	Global	Free	X	X			Offline	https://www.ceres.org/resources/tools/ceres-aqua-gauge-comprehensive-assessment-tool-evaluating-corporate-management
	Aqueduct Water Risk Atlas	WRI	2013	Water	Yes		X		X		X	X	X	X	All	No	Present / Future	Global	Free	X				Online	https://wri.org/applications/aqueduct/water-risk-atlas
ARIES	ARIES	international network of scientists, lead Ferdinando Villa	2007	Ecosystem Services	No				X				X	X	All	No	Present	Global	Free	X				Offline	http://aries.integratedmodelling.org/
BIA	B Impact Assessment	B Corporation	2006	Business impact	No	X				X	X	X			All	No	Present	Global	Free	X	X			Online	https://bimpactassessment.net/
BEST	Benefits of SuDS Tool	susdrain	2015	Blue-green infrastructure	No	X		X			X		X		All	No	Present / Future	UK	Free	X		X		Offline	https://www.susdrain.org/resources/best.html
BioScope	Biodiversity Input-Output for Supply Chain & Operations Evaluation	PRé Sustainability, Arcadis and CODE, commissioned by Platform BEE	2016	Biodiversity	No	X	X			X	X	X		X	All	No	Present	Selected	Free	X	X			Online	https://www.bioscope.info/
BQC	Biodiversity Quality Calculator	Ecosulis	2018	Biodiversity	No	X					X	X	X	X	All	No	Present / Future	Global	Paid	X	X	X		Offline	http://www.ecosulis.co.uk/page/natural-asset-framework
	Co$ting Nature	King's College London + AmbioTEK + UNEP-WCMC	2007	Ecosystem Services	No				X						All	No	Present	Global	Free /paid	X	X	X		Online	http://www.policysupport.org/costingnature

Acronym	Name	Developers		Topic	Water Specific	Form				Audience					Target sector (being valued)	Cases / Special Purpose	Past / Present / Future Value	Geography	Access	Form of assessment				Online / Offline	URL
		Who	When			Calculator	Database	Excel	Software	Private sector - facilities	Private sector - companies	Private sector - investors	Public sector	NGOs & Civil Society						Qualitative	Quantitative	Social-Economic	Financial		
	Cool Farm Tool	PepsiCo, Unilever, Heineken, Marks & Spencer and Tesco	2016	Farming	No	X				X	X				Farm	Yes	Present / Future	Global	Free		X			Online	http://coolfarmtool.org/CoolFarmTool/
CBWCRT	Corporate Bonds Water Credit Risk Tool	NCD + GIZ + VfU Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ) and the German Association for Environment and Sustainability (VfU)	2015	Water	Yes	X		X			X	X			Selected	No	Past / Present	Global	Free		X		X	Online	https://vfu.de/ressourcen/tools/giz-waterrisk
	CSRware	Karen Alonardo	2008	Sustainable business	No	X				X	X				All	No	Present	Global	Paid		X	X		Online	https://csrware.com
	Drought Stress Testing Tool	Natural Capital Finance Alliance (NCFA) and GIZ	2017	Drought Stress	Yes	X		X			X	X			Selected	No	Present / Future	Selected	Free	X				Offline	https://www.unepfi.org/ecosystems/ncfa/drought-stress-testing-tool/
ESVD	Ecosystem service valuation database	TEEB	2010	Ecosystem Services	No		X						X	X	All	No	Past	Selected	Free			X	X	Offline	https://www.es-partnership.org/services/data-knowledge-sharing/ecosystem-service-valuation-database/
ESII	Ecosystem Services Identification & Inventory	TNC, Dow, and EcoMetrix Solutions Group	2017	Ecosystem Services	No				X	X	X		X	X	All	No	Present / Future	USA	Free	X	X	X		Online	https://www.esiitool.com/why-esii
EVT	Ecosystem Valuation Toolkit	Earth Economics	1998	Ecosystem Services	No	X				X	X				All	No	Present	Global	Paid						https://www.eartheconomics.org/ecosystem-valuation-toolkit
ENVALUE	ENVALUE database	New South Wales Environmental Protection Agency	1995	Environmental impact	No		X				X	X	X	X	All	No	Past	Selected	Free			X		Online	https://www.environment.nsw.gov.au/envalueapp/
EP&L	Environmental Profit & Loss	Kering	2012	Environmental impact	No	X					X				Luxury goods	Yes	Present	Selected	Free		X		X	Online	https://www.kering.com/en/sustainability/environmental-profit-loss/
EVRI	Environmental Valuation Reference Inventory	Environment and Climate Change Canada and U.S. Environmental Protection Agency	1997	Environmental impact	No		X				X		X		Selected	No	Present	Selected	Free			X	X	Online	https://www.evri.ca/en
ESE-ROVA	Environmental, Social and Economic: Risk, Opportunity and Valuation Assessment tool	Sustain Value		Environmental impact	No	X				X	X				All	No	Present / Future	Global	Request	X	X	X	X	Offline	http://www.sustainvalue.co.uk/EROVA.php
	Equarius Risk Analytics	AI/ML company with the help of The University of Michigan (UM) and LimnoTech	~2018	Water	Yes	X						X			All	No	Present / Future	Global	Paid		X		X	Offline	https://www.equariusrisk.com/
	estell	systain	2014	Business impact	No	X				X	X				All	No	Present / Future	Global	Paid	X	X			Offline	https://en.systain.com/estell-environmental-footprinting/

Acronym	Name	Developers		Topic	Water Specific	Form				Audience					Target sector (being valued)	Cases / Special Purpose	Past / Present / Future Value	Geography	Access	Form of assessment				Online / Offline	URL
		Who	When			Calculator	Database	Excel	Software	Private sector - facilities	Private sector - companies	Private sector - investors	Public sector	NGOs & Civil Society						Qualitative	Quantitative	Social-Economic	Financial		
ENCORE	Exploring Natural Capital Opportunities, Risks and Exposure	NCFA	2018	Ecosystem Services	No	X	X				X	X	X	X	Selected	No	Present / Future	Global	Free	X				Online	https://encore.naturalcapital.finance/en/
NASA´s eyes	Eyes on the Earth	the California Institute of Technology	2016	Satelite image	No		X		X				X	X	All	No	Past / Present	Global	Free	X				Online	https://eyes.nasa.gov/eyes-on-the-earth.html
	FactSet	FactSet		Portfolio Risks	No	X						X			All	No	Present / Future	Global	Paid		X		X	Offline	https://www.factset.com
	FAOSTAT	FAO	1961	Food and Agriculture data	No		X					X	X	X	Selected	No	Past	Global	Free	X	X			Online	http://www.fao.org/faostat/en/#data
FV Tool	Financial Valuation Tool	IFC, Rio Tinto and Deloitte	2014	Sustainable Business	No	X			X		X	X			All	No	Present / Future	Global	Free	X	X		X	Offline	https://www.fvtool.com/
GEOSS	Global Earth Observation System of Systems	Group on Earth Observations (GEO)		Earth observations	No		X					X	X	X	All	No	Past / Present	Global	Free	X	X			Online	https://www.geoportal.org/
	Global Water Tool™	wbcsd water	2015	Water	Yes	X	X			X	X	X			All + Selected	No	Present / Future	Global + India	Free	X	X			Offline	https://wbcsd.org/Programs/Food-Land-Water/Water/Resources/Global-Water-Tool-old
GIST	Green Infrastructure Support Tool	Earth Genome	2016	Green infrustructure	Yes	X				X	X	X			All	Yes	Present / Future	Global	Paid		X		X	Online	https://www.earthgenome.org
GI-Val	Green Infrastructure Value Toolkit	Green Infrustructure for Tomorrow - Together	2008	Green infrastructure	No	X	X	X		X	X	X	X	X	Green infrastructure	Yes	Present	UK	Free		X	X	X	Offline	https://www.merseyforest.org.uk/services/gi-val/
	GWI Water Data	Global Water Intelligence		Water	Yes		X					X	X		All	No	Past / Present	Global	Paid	X	X		X	Online	https://www.gwiwaterdata.com/
	India Water Tool	wbcsd + WIR + CII-Triveni Water	2019	Water	Yes		X			X	X	X	X	X	All	Yes	Present	India	Free	X	X			Online	https://www.indiawatertool.in/
InVEST	Integrated Valuation of Ecosystem Services and Tradeoffs	Stanford University, the Chinese Academy of Sciences, the University of Minnesota, the Stockholm Resilience Centre, The Nature Conservancy, and the World Wildlife Fund.	2007	Ecosystem Services	No	X	X		X		X	X	X	X	All	No	Present / Future	Global	Free	X	X	X	X	Offline	https://naturalcapitalproject.stanford.edu/invest/
LEFT	Local Ecological Footprinting Tool (LEFT)	Oxford	2017	Biodiversity	No				X		X	X	X	X	All	No	Present	Global	Free /paid	X	X			Online	https://www.left.ox.ac.uk

Acronym	Name	Developers		Topic	Water Specific	Form				Audience					Target sector (being valued)	Cases / Special Purpose	Past / Present / Future Value	Geography	Access	Form of assessment				Online / Offline	URL
		Who	When			Calculator	Database	Excel	Software	Private sector - facilities	Private sector - companies	Private sector - investors	Public sector	NGOs & Civil Society						Qualitative	Quantitative	Social-Economic	Financial		
GEMI	Local Water Tool	Global Environmental Management Initiative (GEMI)	2013	Water	Yes	X				X			X	X	Selected	Yes	Present	Selected	Free	X	X			Offline	http://gemi.org/localwatertool/about.html
	Materiality Map	Sustainability Accounting Standards Board (SASB)	2018	Sustainable business	No		X				X	X	X	X	Selected	No	Present	Global	Free		X			Online	https://materiality.sasb.org/
NCMS	Natural Capital Management Systems	Climate Earth	2013	Natural Capital	No	X				X	X				All	Yes	Present	Selected	Paid		X		X	Online	https://www.climateearth.com/supply-chain-solutions/natural-capital-accounting/
ncpt	Natural Capital Planning Tool	Consultancy for Environmental Economics & Policy (CEEP) in collaboration with Birmingham City Council and the UK Business Council for Sustainable Development (UK BCSD)	2018	Ecosystem Services	No	X		X			X		X	X	All	No	Present / Future	UK	Free	X	X			Offline	http://ncptool.com/
NCP T	Natural Capital Protocol Toolkit	WBCSD	2017	Natural Capital	Some yes	X	X			X	X	X	X	X	all	No	Present / Future Value	Global	Free	X	X	X	X	Online	https://shift.tools/contributors/551
OPAL	Offset Portfolio Analyzer and Locator	Natural Capital Project	2015	Biodiversity	No	X			X		X		X	X	All	No	Present	Global	Free	X	X			Offline	https://naturalcapitalproject.stanford.edu/software/#opal
RIOS	Resource Investment Optimization System	Natural Capital Project + The Nature Conservancy (TNC)	2015	Watershed services	No	X	X		X		X		X	X	All	No	Present	Global	Free	X	X			Offline	https://naturalcapitalproject.stanford.edu/software/
	Save Water Campaign	Colgate Palmolive	2016	Saving Water	Yes	X							X		Selected	Yes	Present	Global	Free	X				Online	https://smiles.colgate.com/page/content/everydropcounts
	SEC Sustainability Disclosure Search	Ceres	2018	Sustainable business	No		X				X	X			Selected	Yes	Past	Selected	Free	N/A	N/A	N/A	N/A	Offline	https://tools.ceres.org/resources/tools/sec-sustainability-disclosure/@@ceres-search-s3?_ga=2.66404071.895364352.1565963934-1201727638.1564482231
SolVES	Social Values for Ecosystem Services	USGS		Ecosystem Services	No	X			X		X		X	X	All	No	Present	Global	Free	X	X			Offline	https://www.usgs.gov/centers/gecsc/science/social-values-ecosystem-services-solves?qt-science_center_objects=0#qt-science_center_objects
SWAT	Soil & Water Assessment Tool	Grassland, Soil & Water Research Laboratory (GSWRL) nor Blackland Research Center (BRC)	2012	Soil + Water	No	X			X				X	X	All	No	Past / Present	Global	Free	X	X			Offline	https://swat.tamu.edu/software/
	Sustainability Measurement and Reporting System	The Sustainability Consortium		Business impact	No	X				X	X	X			Retail	Yes	Present	Global	Paid	X	X			Offline	https://www.sustainabilityconsortium.org/about/#av_section_4
	The Madingley Model	Microsoft		Ecosystem Services,, biodiversity	No				X				X	X	All	No	Present / Future	Global	Free	X				Offline	https://madingley.github.io/

Acronym	Name	Developers		Topic	Water Specific	Form				Audience					Target sector (being valued)	Cases / Special Purpose	Past / Present / Future Value	Geography	Access	Form of assessment				Online / Offline	URL
		Who	When			Calculator	Database	Excel	Software	Private sector - facilities	Private sector - companies	Private sector - investors	Public sector	NGOs & Civil Society						Qualitative	Quantitative	Social-Economic	Financial		
ToSIA	Tool for Sustainability Impact Assessment	European Forest Institute	2010	Business impact	No	X			X	X	X	X	X	X	Forest	Yes	Present / Future	Global	Paid	X	X	X		Offline	http://tosia.efi.int/
TESSA	Toolkit for Ecosystem Service Site-Based Assessment	Birdlife.org	2017	Ecosystem Services	No	X			X	X			X	X	All	No	Present	Global	Free	X	X			Offline	http://tessa.tools/
TIMM	Total Impact Measurement and Management	pwc	2013	Environmental & Social impact	No	X				X	X	X			All	No	Present / Future	Global	Paid		X	X	X	Online	https://www.pwc.com/gx/en/services/sustainability/total-impact-measurement-management.html
	True Cost of Water	Veolia	2013	True Price	Yes	X				X	X	X	X		All	No	Present	Global	Paid	X	X	X	X	Online	https://www.veolia.com/en/citizens/innovation/true-cost-water
	True Cost of Water Toolkit (BIER)	Beverage Industry Environmental Roundtable (BIER)	2015	True Price	Yes	X		X		X	X				Beverage	Yes	Present	Global	Free				X	Offline	https://www.bieroundtable.com/publication/true-cost-of-water-toolkit/
	True Value	KPMG	2014	Business impact	No	X				X	X				All	No	Present	Global	Paid	X	X	X	X	Offline	https://home.kpmg/xx/en/home/services/advisory/risk-consulting/internal-audit-risk/sustainability-services/kpmg-true-value-services.html
	Water Calculation Tool for the Textile Wet Processing Sector	United Nations Development Organisation (UNIDO)	2017	Water	Yes	X				X	X				Textile	Yes	Present	Global	Free		X			Online	https://watercalculator.dnvgl.com/
Wiix	Water Impact Index	Veolia	2014	Business impact	Yes	X				X	X		X		Selected	No	Present	Selected	Free		X			Online	https://www.veolia.com/en/water-impact-index-wiix
	Water Risk Filter	WWF + DEG	2012	Water	Yes	X	X			X	X	X	X	X	All	No	Present	Global	Free	X	X			Online	https://waterriskfilter.panda.org/
	Water Risk Monetizer Tool	Ecolab, Microsoft, trucost	2014	Water	Yes	X				X	X	X			All	No	Present / Future	Global	Free		X		X	Online	https://tool.waterriskmonetizer.com
WRVT	Water Risk Valuation Tool	Bloomberg LP, the Natural Capital Declaration, and the UN Environment Programme Finance Initiative	2015	Water	Yes	X			X	X	X	X	X		Mining	Yes	Present / Future	Global	Paid		X		X	Online	https://www.bbhub.io/sustainability/sites/6/2015/09/Bloomberg_WRVT_09162015_WEB.pdf
	Water Scarcity Atlas	Water & Development Research Group at Aalto University	2016	Water	Yes		X					X	X	X	All	No	Past / Present / Future	Selected	Free	X	X			Online	https://waterscarcityatlas.org

Acronym	Name	Developers		Topic	Water Specific	Form				Audience					Target sector (being valued)	Cases / Special Purpose	Past / Present / Future Value	Geography	Access	Form of assessment				Online / Offline	URL
		Who	When			Calculator	Database	Excel	Software	Private sector - facilities	Private sector - companies	Private sector - investors	Public sector	NGOs & Civil Society						Qualitative	Quantitative	Social-Economic	Financial		
	WaterMAPP	Environmental Defense Fund (EDF), AT&T and the Global Environmental Management Institute (GEMI)	2014	Water efficency	Yes	X				X	X				Buildings, cooling	Yes	Present	USA	Free		X		X	Offline	https://business.edf.org/projects/featured/water-efficiency-and-att/water-efficiency-toolkit-2
	WaterWorld	King's College London	2008	Water	Yes		X								All	No	Present	Global	Free /paid	X	X			Online	http://www.policysupport.org/waterworld
	WeSustain	Dr. Manfred Heil+ others	2010	Sustainable business	No				X						All	No	Present / Future	Global	Paid					Online	https://www.wesustain.com/en/software-solutions/
	World Water Atlas	HLPW Action Plan	2016	Water	Yes		X				X	X	X	X	All	No	Present	Selected	Free	X	X			Online	https://www.worldwateratlas.org

7.3. Tools, frameworks and guidelines descriptions

The following table contains description for all reviewed frameworks, guidelines and tools. The description text is a citation from the official descriptions.

Table 12. Descriptions of reviewed frameworks, guidelines and tools (as on 01.09.2019)

Acronym	Name	Description (in their own words)
2030WRG	2030 Water Resource Group	The partnership supports country-level collaboration designed to unite diverse groups with a common interest in the sustainable management of water resources.
A4S	Accounting for Sustainability	Focuses on the role CFOs play in integrating environmental and social issues into financial decision making.
	Aqua Gauge	A flexible Excel-based tool and associated methodology that allows investors to scorecard a company's water management activities against detailed definitions of leading practice. Developed through a nine-month consultation process with representatives from over 50 investment and financial institutions, companies, conservation groups, and other organizations active on water-related issues, the Ceres Aqua Gauge builds on the foundation outlined by The Ceres Roadmap for Sustainability—and like the Ceres Roadmap, it focuses on governance and management, stakeholder engagement and disclosure.
	AquaWatch	Created to develop and build the global capacity and utility of Earth Observation-derived water quality data, products and information to support water resources management and decision making.
	Aqueduct Water Risk Atlas	A mapping tool helps companies, investors, governments, and other users understand where and how water risks and opportunities are emerging worldwide. The Atlas uses a robust, peer reviewed methodology and the best-available data to create high-resolution, customizable global maps of water risk.
ARIES	ARIES	ARIES strives to quantify the benefits that nature provides to society in a manner that accounts for dynamic complexity and its consequences, but keeps models clear enough to users to remain understandable, usable, and adaptable to conditions of varying data availability.
BIA	B Impact Assessment	A free, confidential platform designed to help measure and manage your company's positive impact on your workers, community, customers and environment. The BIA assesses the impact of both your company's day-to-day operations and your business model—both what you do and how you do it. Your responses to the B Impact Assessment determine your total numeric score. B Corp Certification requires a minimum verified total score of 80 across all impact areas.
	B Team	Founded in the belief that the private sector can, and must, redefine both its responsibilities and its own terms of success, we are developing a 'Plan B' – for concerted, positive action that will ensure business becomes a driving force for social, environmental and economic benefit. Plan A – where business has been motivated primarily by profit – is no longer an option.
BEST	Benefits of SuDS Tool	Helps practitioners estimate the impacts and benefits of Sustainable Urban Drainage Systems (SuDS). It uses ecosystem services to understand the overall benefits that SuDS provide over conventional piped drainage and estimates the economic value of the benefits.
BioScope	Biodiversity Input-Output for Supply Chain & Operations Evaluation	Platform BEE's BioScope provides businesses with a simple and fast indication of the most important impacts on biodiversity arising from their supply chain.

BQC	Biodiversity Quality Calculator	As a pioneering, highly experienced consultancy and contractor, Ecosulis has already protected and enhanced biodiversity at multiple sites across the United Kingdom. Underpinned by our investment in cutting edge research, innovation and technology, we continue to create and manage landscape-scale habitats that support wild nature and enrich people's lives.
BSR EWG	BSR Ecosystem Services Working Group	A global non-profit organization that works with its network of more than 250 member companies and other partners to build a just and sustainable world. From its offices in Asia, Europe, and North America, BSR™ develops sustainable business strategies and solutions through consulting, research, and cross-sector collaboration. Learn more about BSR's 25 years of leadership in sustainability.
CNCIG	Cambridge Natural Capital Impact Group	A global network of companies, working collaboratively, to determine how business can sustain the natural world and its resources through its strategies and operating practices. The Group aims to influence its industry peers through the example of business practice, drawing on research-informed knowledge, processes and tools. Through its engagement with governments and the financial system, the Group seeks to create the economic conditions necessary for these practices to achieve scalable action.
	CDP Water	CDP, formerly the Carbon Disclosure Project, runs the global disclosure system that enables companies, cities, states and regions to measure and manage their environmental impacts. We have built the most comprehensive collection of self-reported environmental data in the world. Our network of investors and purchasers, representing over $100 trillion, along with policy makers around the globe, use our data and insights to make better-informed decisions. Through our offices and partners in 50 countries we have driven unprecedented levels of environmental disclosure.
	Co$ting Nature	A web-based policy-support tool for natural capital accounting and analysis of the ecosystem services provided by natural environments. The focus is on costing nature (understanding the resource, e.g. the land area, and the opportunity cost of protecting nature to produce ecosystem services) as opposed to valuing nature (i.e. how much someone is willing to pay for it). The tool estimates the current provision of water, carbon and tourism services and identifies the beneficiaries, then analyses current environmental pressures, future threats and conservation priority. Users can then apply scenarios for climate, land-use or land management change, and examine the impacts on ecosystem services and the implications for beneficiaries. The tool can be used to assess the impacts of human interventions for conservation prioritisation and planning.
	Cool Farm Tool	Water footprints can be cumbersome and data intensive. But the Cool Farm Tool water metrics enable farmers to quickly and easily account for their crops' water needs and gain insight into better practice.
CBWCRT	Corporate Bonds Water Credit Risk Tool	This new tool enables users for the first time to quantify and integrate financial risk exposure to water scarcity into standard financial models which can then be used to assess the credit strengths of corporates across the three water-intensive sectors
ESR	Corporate Ecosystem Services Review	It consists of a structured methodology that helps managers proactively develop strategies to manage business risks and opportunities arising from their company's dependence and impact on ecosystems. It is a tool for strategy development, not just for environmental assessment. Businesses can either conduct an Ecosystem Services Review as a stand-alone process or integrate it into their existing environmental management systems. In both cases, the methodology can complement and augment the environmental due diligence tools companies already use. The Ecosystem Services Review can provide value to businesses in industries that directly interact with ecosystems such as agriculture, beverages, water services, forestry, electricity, oil, gas, mining, and tourism. It is also relevant to sectors such as general retail, healthcare,

		consulting, financial services, and others to the degree that their suppliers or customers interact directly with ecosystems. General retailers, for example, may face reputational or market risks if some of their suppliers are responsible for degrading ecosystems and the services they provide.
CNCA	Corporate Natural Capital Account	Enabling organisations to gather natural capital information in a coherent and comparable format will help both companies and policy-makers make better informed decisions about the management of natural capital.
	CSRware	Helps companies measure and manage the sustainability risks and opportunities most likely to impact value.is the ultimate platform to measure, manage and taking action on corporate and supply chain environmental, social and governance (ESG), governance, risk and compliance (GRC) and sustainability programs.
	Drought Stress Testing Tool	Allows financial institutions to see how incorporating drought scenarios changes the perception of risk in their own loan portfolios. Based on the catastrophe modelling framework that the insurance industry has used for 25 years, it looks at five drought scenarios in four countries – Brazil, China, Mexico and the US – to model the impact on 19 different industry sectors, the companies in those sectors and the likelihood that they will default on their loans.
ESVD	Ecosystem service valuation database	The database on monetary values of ecosystem services which now contains over 1350 data-points from over 300 case studies
ESII	Ecosystem Services Identification & Inventory	Using the ESII Field App, you can download mapping for your property, go into the field and collect spatially explicit ecological data for your site. In the ESII Project Workspace, you can review and edit the data once you have returned from the field, run the ESII Tool's ecological models, and generate results in a variety of user-friendly formats.
EVT	Ecosystem Valuation Toolkit	The foundation of our work to quantify and value the benefits nature provides. By dramatically simplifying the calculation of economic values for natural capital, the EVT fills an essential role in the transition to a sustainable economy. Specifically, it offers a reliable, scalable source for data to support decision making that fully values nature. The EVT combines a comprehensive database of academically sound, fully defensible, monetary values for natural assets with standardized biophysical attributes and a sophisticated suite of web-based tools.
ENVALUE	ENVALUE database	A systematic collection of environmental valuation studies presented in an on-line database. It is expected that the ENVALUE database will assist decision makers in government and industry as well as academics, consultants and environmental groups, to incorporate environmental values into cost-benefit analyses, environmental impact statements, project appraisals and overall valuation of changes in environmental quality.
EP&L	Environmental Profit & Loss	The EP&L measures carbon emissions, water consumption, air and water pollution, land use, and waste production along the entire supply chain, thereby making the various environmental impacts of the Group's activities visible, quantifiable, and comparable. These impacts are then converted into monetary values to quantify the use of natural resources. Kering can thus use the EP&L to guide its sustainability strategy, improve its processes and supply sources, and choose the best-adapted technologies.
EVRI	Environmental Valuation Reference Inventory	A searchable compendium of summaries of environmental and health valuation studies. These summaries provide detailed information about the study location, the specific environmental assets being valued, the methodological approaches and the estimated monetary values along with proper contextualization. The EVRI database now contains over 4,000 summaries of valuation studies and information from new studies is being added on an ongoing basis.
ESE-ROVA	Environmental, Social and Economic: Risk, Opportunity and Valuation Assessment tool	It is an integrated 'framework' based Excel tool that aligns with the Natural and Social Capital Protocols. A key advantage of the tool is that it can be adapted for many different business applications for any sector.

	Equarius Risk Analytics	Our index platform provides mainstream financial risk metrics capturing embedded water risk through a volatility risk premium. Our patent-pending learning algorithms were developed with The University of Michigan (UM) and LimnoTech, an environmental services firm. Equarius Risk Analytics has secured an all fields of use license from UM.
	estell	Modern sustainability management is dedicated to the corporate operations which have significant impacts on the environment and the society. estell offers the essential transparency about hot-spots in the supply chain and identifies appropriate mitigation and reduction measures. Especially the assessment of consumed natural capital and the effects caused by emissions into air, water and soil are in focus.
B@B	EU Business and Biodiversity platform	Provides a unique forum for dialogue and policy interface to discuss the links between business and biodiversity at EU level. It was set up by the European Commission with the aim to work with and help businesses integrate natural capital and biodiversity considerations into business practices.
EBBC	European Business and Biodiversity Campaign	Supports companies in integrating biodiversity into the corporate management. The campaign provides attractive options for sustainability officers and decision makers in enterprises to inform themselves about methods and instruments to evaluate the impact of a company's activities on biological diversity.2010
ENCORE	Exploring Natural Capital Opportunities, Risks and Exposure	Comprehensive database covers 167 economic sectors and 21 'ecosystem services', i.e. the benefits that nature provides that enable or facilitate business production. ENCORE data has identified that the three sectors most materially dependent on nature are: Agriculture, Aquaculture & fisheries and Forest products. Sectors such as Utilities, Oil & gas and Mining were also found to have a very high dependence on ecosystem services. The three most important 'ecosystem services' for the global economy were found to be: Water provision, Climate regulation and Flood protection.
NASA´s eyes	Eyes on the Earth	Displays the location of all of NASA's operating Earth-observing missions in real time and lets you compare them in size to a scientist or a school bus. Get a sneak peek at upcoming missions and learn how NASA is planning to study our Earth in the future. With the "Latest Events" feature, you can explore geo-located satellite images of recent Earth events, including algal blooms, super storms and wildfires.
	FactSet	FactSet enables users to generate interest-specific reports and analyses, synthesizing inputs from a broad array of sources, including fundamental financial data, along with proprietary and third-party datasets such as indices, economic indicators and earnings estimates. ESG datasets available include MSCI, Sustainalytics, Trucost, ISS, and Revere data, which provides insights into supply chain relationships, geographic revenue exposure and revenue hierarchy, is also part of FactSet. In-house consultants assist with report construction and modelling.
	FAOSTAT	Provides free access to food and agriculture data for over 245 countries and territories and covers all FAO regional groupings from 1961 to the most recent year available.
FV Tool	Financial Valuation Tool	The FV Tool allows an organization to test whether its sustainability initiatives will effectively create or protect value for a project and, most importantly, manage risks that could negatively impact project completion and ongoing business operations. And because it uses a data-driven methodology, Return on Investment is expressed in the quantifiable metric of Net Present Value (NPV), which enables sustainability budgets to more effectively compete with other corporate priorities.

GEOSS	Global Earth Observation System of Systems	A set of coordinated, independent Earth observation, information and processing systems that interact and provide access to diverse information for a broad range of users in both public and private sectors. GEOSS links these systems to strengthen the monitoring of the state of the Earth. It facilitates the sharing of environmental data and information collected from the large array of observing systems contributed by countries and organizations within GEO. Further, GEOSS ensures that these data are accessible, of identified quality and provenance, and interoperable to support the development of tools and the delivery of information services. Thus, GEOSS increases our understanding of Earth processes and enhances predictive capabilities that underpin sound decision-making: it provides access to data, information and knowledge to a wide variety of users.
	Global partnership for Business and Biodiversity	A network of networks linking the various initiatives so that they can share information and good practices and cooperate on common projects with a view to mainstreaming biodiversity concerns into businesses. The Global Partnership gets also involved in select COP mandated projects.
	Global Platform on Business and Biodiversity tools and Mechanisms	The Global Platform for Business and Biodiversity supports the business engagement activities of the Secretariat of the Convention on Biological Diversity including the Global Partnership for Business and Biodiversity. Here you will find a variety resources designed to inform Parties to the Convention and other stakeholders about the business engagement activities as well as information and tools for businesses wishing to better understand their impacts and dependencies on biodiversity and ecosystem functions and services, and take action to address these issues.
	Global Water Tool™	is a free, publicly available resource for identifying corporate water risks and opportunities which provides easy access to and analysis of critical data. It includes a workbook (data input, inventory by site, key reporting indicators, metrics calculations), a mapping function to plot sites with datasets, and a Google Earth interface for spatial viewing.
GIST	Green Infrastructure Support Tool	Earth Genome’s platform is Geographic Information System (GIS) based and models spatial and temporal conditions providing environmental and financial performance metrics. The tool uses data from public agencies (NOAA, NASA, USGS, Corps of Engineers, census), NGOs and private sources. Platform uses detailed map interface to evaluate scenarios associated with water security and other natural resource challenges on an effectiveness and financial basis, to facilitate investment and operational changes, and guide the development of science and context-based goals. Earth Genome team available to build customized regional platform for end-user needs. End users can enter their own datasets, also.
GI-Val	Green Infrastructure Value Toolkit	A toolkit, a manual and inspirational example that will help communities, businesses and governments to enhance their green environment, or Green Infrastructure. In five case studies, we tested and developed tools for bottom up planning of Green infrastructure and came up with generic road maps. We engaged and brought together communities, businesses and governments and facilitated a process of joint goal setting, mapping of the green infrastructure and ecosystem services, designing of scenario’s and making arrangements for implementation. We assessed the role of valuation and how the enhancements of green infrastructure can improve the natural habitats.
	GWI Water Data	The culmination of this expansive research portfolio, the goal is to bring our research together in a single, intuitive online platform that makes it easy for our customers to access intelligence that will drive their business forward in the touch of a button.
	India Water Tool	The India Water Tool 3.0 brings together datasets and risk indicators from the Government of India and other institutions, to help users understand their water risks and plan interventions for water management in India.

InVEST	Integrated Valuation of Ecosystem Services and Tradeoffs	InVEST enables decision makers to assess quantified trade-offs associated with alternative management choices and to identify areas where investment in natural capital can enhance human development and conservation. The toolset currently includes eighteen distinct ecosystem service models designed for terrestrial, freshwater, marine, and coastal ecosystems, as well as a number of "helper tools" to assist with locating and processing input data and with understanding and visualizing outputs.
	ISO 14008:2019	Monetary valuation of environmental impacts and related environmental aspects.
	ISO/FDIS 14007	Environmental management - guidelines for determining environmental costs and benefits
	IUCN's Water Programme	Brings together its extensive network of IUCN Members, experts, government and private sector partners to develop sustainable solutions to preserve our water resources.
LfN	Leaders for Nature	Engages multinationals to work towards greening the economy. By offering knowledge and training, hands-on project support and inspiration, LfN stimulates and facilitates companies to take the lead on incorporating natural capital into their core business. Since its inception, the LfN network has connected more than 1,200 professionals from various management levels with member companies, NGOs, governments and academic institutions, resulting in corporate action plans and joint programmes.
	LIFE Methodology	To calculate the organization's impacts on biodiversity, environmental aspects are considered, such as the consumption of energy and water, waste generation, emissions of greenhouse gases and area occupation, considering both their quantity and their severity.
LEFT	Local Ecological Footprinting Tool (LEFT)	A web-based decision support tool which can help businesses minimise the environmental impacts of their activities when they make decisions about how land is used. A user defines an area of interest anywhere in the world using a web-based map and LEFT automatically processes a series of high-quality datasets using standard published algorithms to produce:
GEMI	Local Water Tool	a free tool for companies and organizations to evaluate the external impacts, business risks, opportunities and management plans related to water use and discharge at a specific site or operation. The information generated in the GEMI LWT™ may be used by companies for internal or external communication at their discretion. The GEMI Local Water Tool™(LWT) for Oil and Gas is a tool customized for petroleum companies.
	Materiality Map	identifies sustainability issues that are likely to affect the financial condition or operating performance of companies within an industry. In the left-hand column, SASB identifies 26 sustainability-related business issues, or General Issue Categories, which encompass a range of Disclosure Topics and their associated Accounting Metrics that vary by industry. For example, the General Issue Category of Customer Welfare encompasses both the Health and Nutrition topic in the Processed Foods industry and the Counterfeit Drugs topic in the Health Care Distributors industry.
	Natural Capital Analyzer	Trucost report demonstrates how natural capital data is helping companies to grow business value in an environmentally challenged economy.
	Natural Capital Assessments at the National and Sub-national Level	A stepwise guidance document to conducting a natural capital assessment. The steps presented in the guide are designed around sets of key questions, together with practical checklists of actions. The assessment process set out is designed to provide an evidence base for understanding and mapping the distribution of natural capital, evaluating its status and trends, and exploring its relationship with priority economic sectors and livelihoods. In turn the information collated through the assessment process will help to inform the development of policy targets for sustainable management and improvement of natural capital and the transition to a green economy over time.

NCC	Natural Capital Coalition	While the Coalition was primarily set up to focus on embedding natural capital thinking and assessments in the private sector, since the launch of the internationally recognised Natural Capital Protocol in 2016, our focus has broadened. The Coalition is now also working to develop and encourage an international 'enabling environment' for natural capital approaches. This environment will cultivate the climate necessary to support the transition to a society in which the natural capital approach is an integral part of public and private decision-making.
NCFA	Natural Capital Finance Alliance	A finance-led initiative to integrate natural capital considerations into loans, public and private equity, and fixed income and insurance products.
NCMS	Natural Capital Management Systems	NCMS is built for companies that understand how critical access to and preservation of natural resources is to their business. They want to better understand their resource dependencies as well as know the likely location of the impact. They want to communicate about environmental impacts by using easy to recognize common monetary units.
ncpt	Natural Capital Planning Tool	The Natural Capital Planning Tool (NCPT) is a free site assessment tool developed specifically for the planning context. The NCPT allows the indicative but systematic assessment of the likely impact of proposed plans and developments on Natural Capital and the ecosystem services it provides to people such as recreational opportunities, air quality regulation and climate regulation.
NCP	Natural Capital Protocol	The Protocol Framework (figure 0.1) covers four stages, "Why", "What", "How" and "What Next". These Stages are further broken down into nine Steps, which contain specific questions to be answered when integrating natural capital into organizational processes. Although set out in a linear way, the Protocol is iterative and allows users to adjust and adapt their approach as they progress through the framework.
NCP T	Natural Capital Protocol Toolkit	Who is the toolkit for? - Businesses who need help measuring a specific aspect of natural capital, for example water, waste or biodiversity. - Businesses who want to understand which natural capital measurement tools are out there, and how they differ. - Tool developers who believe businesses would benefit from using their publicly-available tools
NVI	Natural Value Initiative Toolkit	The toolkit helps to: - Evaluate how well the food, beverage and tobacco (FBT) sectors are managing biodiversity and ecosystem services risks and opportunities; and - Engage with FBT companies to reduce their risk exposure through the responsible management and harvesting of natural resources
	OECD Water	The OECD provides policy guidance on water to OECD members and non-OECD countries, covering a wide range of issues.
OPAL	Offset Portfolio Analyzer and Locator	A free, open-source software tool that enables users to quantify the impacts of infrastructure development projects locally, and to assess the benefits of mitigation options for both ecosystem services and biodiversity.
	Oppla	It provides a knowledge marketplace, where the latest thinking on natural capital, ecosystem services and nature-based solutions is brought together. Its purpose is to simplify how we share, obtain and create knowledge to better manage our environment. Oppla is an open platform that is designed for people with diverse needs and interests - from science, policy and practice; public, private and voluntary sectors; organisations large and small, as well as individuals. All are welcome and have a part to play in our community.
	Oxford Sustainable Finance Programme	We research environment-related risks, impacts, and opportunities across different sectors, geographies, and asset classes; how such factors are emerging and how they positively or negatively affect asset values; how they might be interrelated or correlated; their materiality (in terms of scale, impact, timing, and likelihood); who will be affected;

		and what affected groups can do to pre-emptively manage risk. Since our inception we have conducted pioneering research on stranded assets and continue to undertake significant research on the topic.
PA-BAT	Protected Areas Benefits Assessment Tool	Designed to fill an important gap in the toolbox of protected area agencies and conservation institutions, by providing a methodology to collate and build information about the overall benefits from protected areas. As pressures on protected areas continue to develop over time, and demand for land and water, and for management resources, is increasingly stretched, park managers need to have arguments for protection in place and backed by a solid body of data collected over time.
	RECon	A comprehensive, global platform of resources, tools and programs designed to improve energy, water and waste efficiencies in our manufacturing processes, leverages training and technology to identify further opportunities to reduce fuel and electricity consumption in our operations. Deployment of energy efficient lighting, heating and cooling systems, boilers, and motors, combined with operator training, are key to driving energy efficiency in our manufacturing and warehousing operations.
	Replenishment programe	The programe is useful for: - provide access to safe water and improved sanitation (includes water collection and storage facilities, purification processes, and septic systems); - protecting watersheds (includes conserving or restoring water quantity or quality); and - providing water for productive use (includes projects such as rainwater harvesting or water for irrigation).
RIOS	Resource Investment Optimization System	Provides a standardized, science-based approach to watershed management in contexts throughout the world. It combines biophysical, social, and economic data to help users identify the best locations for protection and restoration activities to maximize the ecological return on investment, within the bounds of what is socially and politically feasible.
	Save Water Compain	Globally, the turn-off-the-faucet campaign can lead to a potential reduction of 50 billion gallons of water per year. Since water and wastewater treatment systems are energy intensive, every drop of water saved means less energy used. So, the projected global water savings comes with an additional benefit of approximately two million metric tons of greenhouse gas saved.
	SEC Sustainability Disclosure Search	Helps you understand how companies are tackling material risks and opportunities they face from sustainability issues like climate change, carbon asset risk, water availability and quality, and hydraulic fracturing. Which companies address these issues in regular communications with shareholders? How much—and what—do they say? Has their disclosure changed over time?
SolVES	Social Values for Ecosystem Services	Designed to assess, map, and quantify the perceived social values of ecosystem services. Social values, the perceived, nonmarket values the public ascribes to ecosystem services, particularly cultural services, such as aesthetics and recreation can be evaluated for various stakeholder groups. These groups are distinguishable by their attitudes and preferences regarding public uses, such as motorized recreation and logging. SolVES derives a quantitative, 10-point, social-values metric, the “value index”, from a combination of spatial and nonspatial responses to public value and preference surveys and calculates metrics characterizing the underlying environment, such as average distance to water and dominant landcover.
SWAT	Soil & Water Assessment Tool	A small watershed to river basin-scale model used to simulate the quality and quantity of surface and ground water and predict the environmental impact of land use, land management practices, and climate change. SWAT is widely used in assessing soil erosion

		prevention and control, non-point source pollution control and regional management in watersheds.
	Sustainability Measurement and Reporting System	Designed to assess the global production of a product. This means all regions and customers, unless otherwise noted in the assessment scope or title. Assessing your global production of a product is essential for the ability to simultaneously communicate results to multiple retail customers and gives your and your retail customers a more complete understanding of your sustainability performance. We recognize different impacts are more or less important in different markets. When data and research are being collected, TSC makes special note of assumptions and limitations concerning geographic applicability and includes experts who have knowledge of geo-specific impacts in the discussion.
SPM	Sustainable Portfolio Management Guide	A fact based and robust compass to steer Solvay's portfolio toward better business because more sustainable. SPM is designed to boost Solvay's business performance and deliver higher growth.
TCFD	Task Force on Climate-related Financial Disclosures	The FSB Task Force on Climate-related Financial Disclosures (TCFD) will develop voluntary, consistent climate-related financial risk disclosures for use by companies in providing information to investors, lenders, insurers, and other stakeholders. The Task Force will consider the physical, liability and transition risks associated with climate change and what constitutes effective financial disclosures across industries. The work and recommendations of the Task Force will help companies understand what financial markets want from disclosure in order to measure and respond to climate change risks, and encourage firms to align their disclosures with investors' needs.
TEEB	The Economics of Ecosystems and Biodiversity	A global initiative focused on "making nature's values visible". Its principal objective is to mainstream the values of biodiversity and ecosystem services into decision-making at all levels. It aims to achieve this goal by following a structured approach to valuation that helps decision-makers recognize the wide range of benefits provided by ecosystems and biodiversity, demonstrate their values in economic terms and, where appropriate, suggest how to capture those values in decision-making.
	The Madingley Model	An entirely new approach to modelling ecosystems and biodiversity. It is different from existing models as it includes both marine and terrestrial ecosystems, and marine and terrestrial human pressures – fisheries, agriculture, and climate change, for example. It is global in scope but can be applied regionally or nationally and allows for unpredictable behaviour to emerge – meaning that food webs can shift and ecosystems can radically alter. It is published and described in the scientific peer-reviewed literature and is open for anyone to use and modify.
ToSIA	Tool for Sustainability Impact Assessment	Is a decision support tool that was originally developed for the forestry sector, which analyses sustainability impacts of Forest-Wood-Chains (FWCs) and value chains related to resource use. Value chains are chains of production processes that are linked with products. ToSIA compares alternative process chains by using scenarios to analyse the sustainability effects of changes due to deliberate actions (e.g. in policies or business activities) or due to external forces (e.g. climate change, global markets). Impacts are assessed by calculating changes in material flows and indicators of environmental, economic and social sustainability within each forest value chain.
TESSA	Toolkit for Ecosystem Service Site-Based Assessment	The TESSA toolkit is an easy-to-use workbook that leads the user through the steps needed to assess the ecosystem services provided at a particular site. It is built around a comparison of the site in two alternative states, e.g. before and after restoration or conversion, and encourages a high level of stakeholder engagement. The toolkit was initially developed for conservation practitioners but can be used by anyone, including those with no prior knowledge of ecosystem services. It includes an introduction to the concepts of ecosystem services and natural capital, guidance on how to conduct a preliminary

		scoping appraisal to identify important services and beneficiaries, decision trees to identify the best methods to use for each service, and links to a set of simple low-cost methods for measuring ecosystem services either qualitatively or quantitatively
	Total Contribution	A methodology which demonstrates the value company rate by measuring the impact of our activity on the capitals on which company depends
TIMM	Total Impact Measurement and Management	The framework puts a value (positive or negative) on impacts across society, tax, economics and the environment. It gives business the ability to compare strategies and investment choices, evaluating the total impact of each. Explore the different scenarios to understand how this could work in practice.
	True Cost of Water	The tool combines traditional CAPEX and OPEX calculations with analysis of water risks and their financial implications. The True Cost of Water tool takes into account: - Direct water costs: Capital & Operational Expenditures of water infrastructures, Indirect water costs: existing costs that are usually not attributed to water, e.g. water-related legal costs, - Financial implications of water risks: costs arising during the lifetime of a plant that were not anticipated
	True Cost of Water Toolkit (BIER)	The True Cost of Water Toolkit is a pre-designed spreadsheet that can help you quantify the costs associated with your business' water systems.
	True Price	The mission of True Price is to realize sustainable products that are affordable to all by enabling consumers to see and voluntarily pay the true price of products they buy.
	True Value	The KPMG True Value Bridge enables managers to compare and contrast the company's diverse impacts using a common financial metric. It also helps leaders to understand how the company's "true" earnings (including its socio-economic and environmental impacts) compare to its financial earnings.
	Value of Water Framework	The report seeks to bring clarity to a corporate audience, as well as other relevant stakeholders, on how to better understand water valuation, water risks, and the possibilities for better water stewardship.
	Valuing corporate environmental impacts	This short introductory paper is a preface to six methodology papers which present our latest thinking on the valuation of environmental impacts for Environmental Profit and Loss (E P&L) Accounts. The six papers cover impacts associated with: air pollution, greenhouse gases, land use, solid waste, water consumption, and water pollution. The methodologies were originally developed for the E P&L, but are flexible to the objectives of the user and have since been applied in many corporate contexts
	Valuing Nature Programme	The five year, £6.5m Valuing Nature Programme aims to better understand and represent the complexities of the natural environment in valuation analyses and decision making. It will consider the economic, societal and cultural value of ecosystem services. The Programme will fund research and support researchers in making links with policymakers, businesses and practitioners through the Valuing Nature Network.
VWBA	Volumetric water benefit accounting	Provides corporate water stewardship practi-tioners with a standardized approach and set of indicators to estimate and communicate the volumetric water benefits of water stewardship activities.
	Water Action Hub	The Hub helps companies and other organizations address water risk and advance sustainable water management by: - Raising awareness of water stewardship projects around the world and the organizations administering them - Allowing organizations to propose new stewardship projects and garner interest among potential partners - Facilitating water stewardship partners and collective action

	Water Calculation Tool for the Textile Wet Processing Sector	Foreseen projects include developing a water footprint self-assessment tool to assist small and medium size enterprises (SMEs) in developing countries to evaluate their water footprint in restricted stages of a product life cycle, specifically the so-called 'cradle-to-gate' assessment from agricultural production through processing and production up to the factory gate (i.e. before the product is transported to the consumer). DNV GL and Unido offer this free available web-based Water Calculation Tool for the Textile Wet Processing Sector - going into depth of process units.
	Water Funds Toolbox	Water Funds enable downstream water users - like cities, businesses, and utilities - to invest in upstream land management to improve water quality and quantity and generate long-term benefits for people and nature.
Wiix	Water Impact Index	A tool developed by Veolia to measure the impact of activities on a local water resource. It is unique in that it integrates volume, quality and local stress factors into a single indicator. The Water Impact IndeX conforms to current requirements of the ISO 14046:2014 standard related to water footprint assessment.
	Water Risk Filter	The Water Risk Filter uses 32 annually updated, peer reviewed data layers along with a site-based operational risk questionnaire to enable users to understand and prioritize water risks and specific sites. Designed to be easy to use by non-water experts, this is the only water risk tool to assess both basin and operational risks. In the Respond section, the Water Risk Filter dynamically links your risk assessment results to provide a customized set of recommended response actions. Whether you want recommendations for 1 site, 10 sites or 1000 sites, the Respond section can offer tailored response actions at just the click of a button. Already a trusted online tool for corporate water risk assessment, the Water Risk Filter 5.0 will guide users along their water stewardship journey from assessment to response to water risks.
	Water Risk Monetizer Tool	Helps you assess water-related business risks in order to understand the gap between what your business pays for water and the potential costs of water risks to your business.
	Water Risk Valuation Model	A modeling platform to quantitatively assess mining-related water and environmental risks and their financial implications. The modeling platform provides investors access to a targeted analysis of water-related mining risk, with a high level of specificity related to the type of mining operation, geophysical and socio-political setting, remediation and mitigation needs, financial implications of particular asset risks on the broader company portfolio, and causal connections between risk factors and financial performance.
WRVT	Water Risk Valuation Tool	A demonstration project that illustrates how water risk can be incorporated into a standard discounted cash flow (DCF) model to inform the valuation of companies in the mining sector. Developed by project partners Bloomberg LP and the Natural Capital Declaration (NCD), the WRVT is designed to be a conversation starter around the feasibility and efficacy of integrating natural capital considerations—specifically, water risk—into well-established modes of analyzing company value.
	Water Scarcity Atlas	Provides an introduction to water scarcity, and showcases analyses that cover the whole world, based on cutting edge research. Helps to: - Learn about water scarcity - Explore how water scarcity has developed - Test how water scarcity might change in future, exploring opportunities for change The Atlas aims to share the insights of scientific findings of water scarcity to a broader public and private sector audience.
	WaterMAPP	Developed to help facility managers evaluate a building's water usage and identify opportunities for reducing water consumption. For buildings that utilize cooling towers, the calculator can be used to calculate consumption and cost savings associated with improved

		operational efficiency of their cooling systems and increased free air cooling.
	WaterWorld	WaterWorld is a testbed for the development and implementation of land and water related policies for sites and regions globally, enabling their intended and unintended consequences to be tested in silico before they are tested in vivo. WaterWorld can also be used to understand the hydrological and water resources baseline and water risk factors associated with specific activities under current conditions and under scenarios for land use, land management and climate change. It incorporates detailed spatial datasets at 1-square km and 1-hectare resolution for the entire world, spatial models for biophysical and socio-economic processes along with scenarios for climate, land use and economic change. A series of interventions (policy options) are available which can be implemented, and their consequences traced through the socio-economic and biophysical systems. The model integrates with a range of geobrowsers for immersive visualisation of outcomes.
WAVES	Wealth Accounting and the Valuation of Ecosystem Services	Aims to promote sustainable development by ensuring that natural resources are mainstreamed in development planning and national economic accounts This global partnership brings together a broad coalition of UN agencies, governments, international institutes, nongovernmental organizations and academics to implement Natural Capital Accounting (NCA) where there are internationally agreed standards, and develop approaches for other ecosystem service accounts. By working with central banks and ministries of planning and finance across the world to integrate natural resources into development planning through NCA, we hope to enable more informed decision making that can ensure genuine green growth and long-term advances in wealth and human well-being.
	WeSustain	Our goal is to make sustainability an integral part of organizations, both in private as well as public sector. The most important factor for us is close contact, involving our customers and partners to lay the foundation of continuous improvement for our tools and our company overall. Of course, we realize the sustainability concept in our daily corporate activities and officially support the United Nations Global Compact. Furthermore, we release the SUSTAINABLE Code Declaration of Conformity every year and assume responsibility as a company that takes on trainees.
	White Paper: Valuing Water to Drive More Effective Decisions	The White Paper aims to spark discussion among stakeholders in the water industry, regulators and researchers to assist in integrating the total economic value of water into decision–making. Yarra Valley Water commissioned Trucost to calculate the value of water to Melbourne.
	World Water Atlas	For all people and their leaders who want to understand and address the multifaceted risk related to water, The World Water Atlas is an interactive platform that marks water risk ‘hotspots,’ where challenges and opportunities collide. The Atlas is presented in compelling narratives backed by reliable open-source data.

7.4. Results from WRM application

The results for the Company water risks costs calculation after application the Water Risk Monetizer tool (normal scenario):

FACILITY REPORT FOR **THE COMPANY**

Trujillo, La Libertad, Peru

Industry classification: **Other Vegetable (except Potato) and Melon Farming**

Incoming Water	Outgoing Water	Water Risk Premium	Revenue at Risk	Rank
13,150,000.00	**1,000,000.00**	**382.0x**	**1%**	**1**
m^3 per year	m^3 per year	Relative to price for incoming and outgoing water	Potential revenue at risk due to water quantity risk	Based on water quantities, monetized risk and likelihood

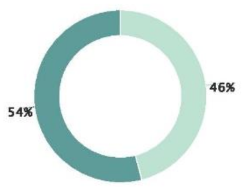
Facility Data

Incoming Water Price (USD per m^3)	$0.01
Incoming Risk Adjusted Price (USD per m^3)	$2.04
Outgoing Water Price (USD per m^3)	$0.02
Outgoing Risk Adjusted Price (USD per m^3)	$31.19

Total Facility Output per Year	37,500
Facility Outputs (units of measure)	tonn
Projected Facility Output (Growth) Over 3 years	30.00%
Revenue (USD)	$160,000,000

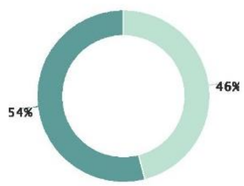
Total Risk Premium

The Total Risk Premium is a monetary estimate of the full value of water to the facility. It is the sum of the incoming risk premium (based on quantity and quality) and the outgoing risk premium (based on quality risk).



Risk source: Incoming vs. Outgoing water

Incoming
Outgoing



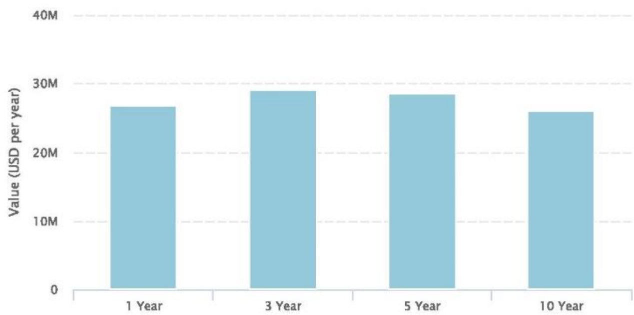
Risk Factor: Quantity vs. Quality water

Quantity
Quality

Incoming Risk

Incoming Risk Likelihood Score:
HIGH

Incoming water risk premium places a monetary value on the local environmental, human-health and domestic supply impacts of water depletion and the future costs of incoming water treatment.



USD per year	1 year	3 year	5 year	10 year
Quality Risk	0	0	0	0
Quantity Risk	26,702,950	28,915,174	28,467,650	25,839,630
Water Bill	131,500	159,115	161,428	185,162
Combined	**26,834,450**	**29,074,290**	**28,629,076**	**26,024,792**

Risk Adjusted Unit Pricing (USD per m^3)	1 year	3 year	5 year	10 year
Quality Risk Premium	0.00	0.00	0.00	0.00
Quantity Risk Premium	2.03	2.00	1.97	1.79
Water Bill Unit Price	0.01	0.01	0.01	0.01
Combined Risk Adjusted Price	**2.04**	**2.01**	**1.98**	**1.80**

Date: 22/9/2019

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FACILITY REPORT FOR **THE COMPANY**

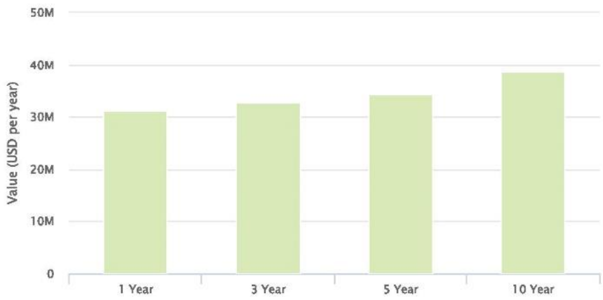
Trujillo, La Libertad, Peru

Industry classification: **Other Vegetable (except Potato) and Melon Farming**

Outgoing Risk

Outgoing Risk Likelihood Score:
HIGH

Outgoing water risk premium places a monetary value on the local environmental and human-health impacts of water pollution and the future costs of water treatment.



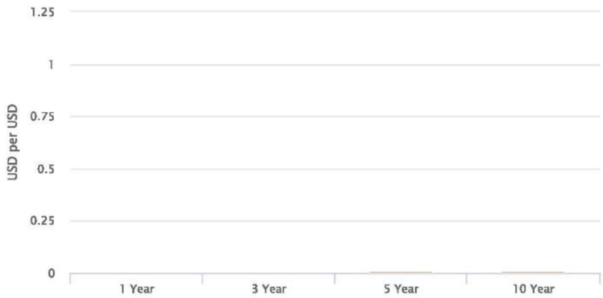
USD per year	1 year	3 year	5 year	10 year
Quality Risk	31,168,514	32,698,742	34,291,416	38,641,800
Water Bill	20,000	28,600	25,536	30,767
Combined	**31,188,514**	**32,727,342**	**34,316,952**	**38,672,568**

Risk Adjusted Unit Pricing (USD per m^3)	1 year	3 year	5 year	10 year
Quality Risk Premium	31.17	29.73	31.17	35.13
Water Bill Unit Price	0.02	0.03	0.02	0.03
Combined Risk Adjusted Price	**31.19**	**32.73**	**34.32**	**38.67**

Revenue Risk

Revenue Risk Likelihood Score:
LOW

Revenue at risk compares the estimated amount of water a business requires to generate revenue (m^3 per USD of revenue) to the business' share of water available in the water basin if water were allocated among water users based on economic activity (contribution to basin-level GDP). If more water is required than the basin share of water allocated, then a proportion of the business' revenue is potentially at risk.



USD per year	1 year	3 year	5 year	10 year
Revenue At Risk (USD per USD)	0.00	0.00	0.01	0.01

The results for the Company water risks costs calculation after application the Water Risk Monetizer tool (drought scenario):

FACILITY REPORT FOR **THE COMPANY**

Trujillo*, La Libertad, Peru

Industry classification: **Other Vegetable (except Potato) and Melon Farming**

Incoming Water	Outgoing Water	Water Risk Premium	Revenue at Risk	Rank
13,150,000.00	**1,000,000.00**	**81,343.6x**	**100%**	**1**
m^3 per year	m^3 per year	Relative to price for incoming and outgoing water	Potential revenue at risk due to water quantity risk	Based on water quantities, monetized risk and likelihood

Facility Data

Incoming Water Price (USD per m^3)	$0.01	Total Facility Output per Year	37,500
Incoming Risk Adjusted Price (USD per m^3)	$934.79	Facility Outputs (units of measure)	tonn
Outgoing Water Price (USD per m^3)	$0.02	Projected Facility Output (Growth) Over 3 years	30.00%
Outgoing Risk Adjusted Price (USD per m^3)	$31.19	Revenue (USD)	$160,000,000

Total Risk Premium

The Total Risk Premium is a monetary estimate of the full value of water to the facility. It is the sum of the incoming risk premium (based on quantity and quality) and the outgoing risk premium (based on quality risk).

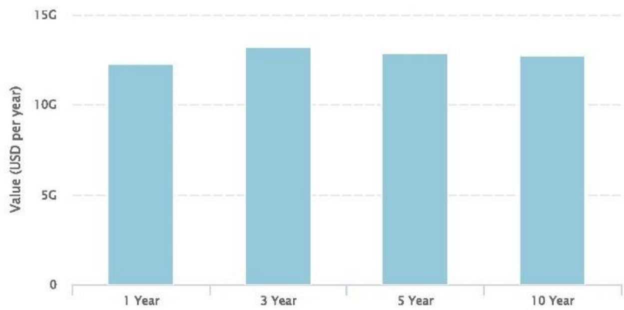
Risk source: Incoming vs. Outgoing water
Incoming
Outgoing

Risk Factor: Quantity vs. Quality water
Quantity
Quality

Incoming Risk

Incoming Risk Likelihood Score:
HIGH

Incoming water risk premium places a monetary value on the local environmental, human-health and domestic supply impacts of water depletion and the future costs of incoming water treatment.



USD per year	1 year	3 year	5 year	10 year
Quality Risk	0	0	0	0
Quantity Risk	12,292,387,840	13,201,499,136	12,888,955,904	12,766,486,528
Water Bill	131,500	159,115	161,428	185,162
Combined	**12,292,519,936**	**13,201,658,880**	**12,889,117,696**	**12,766,671,872**

Risk Adjusted Unit Pricing (USD per m^3)	1 year	3 year	5 year	10 year
Quality Risk Premium	0.00	0.00	0.00	0.00
Quantity Risk Premium	934.78	912.65	891.04	882.58
Water Bill Unit Price	0.01	0.01	0.01	0.01
Combined Risk Adjusted Price	**934.79**	**912.66**	**891.05**	**882.59**

Date: 22/9/2019

Water Risk Monetizer The Company Report: Page 1 of 2

FACILITY REPORT FOR **THE COMPANY**

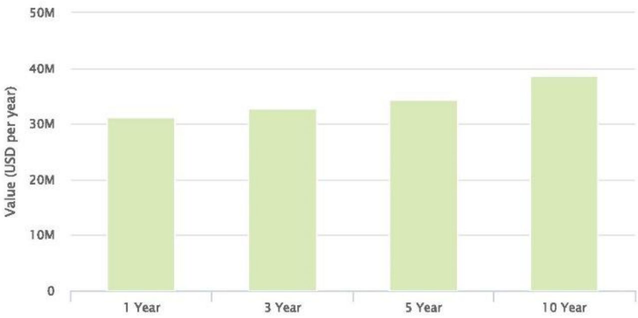
Trujillo*, La Libertad, Peru

Industry classification: **Other Vegetable (except Potato) and Melon Farming**

Outgoing Risk

Outgoing Risk Likelihood Score:
HIGH

Outgoing water risk premium places a monetary value on the local environmental and human-health impacts of water pollution and the future costs of water treatment.



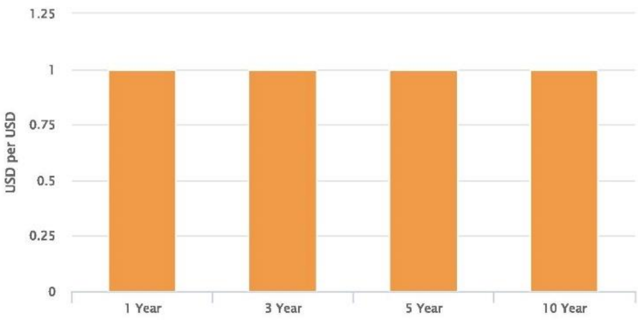
USD per year	1 year	3 year	5 year	10 year
Quality Risk	31,168,514	32,698,742	34,291,416	38,641,800
Water Bill	20,000	28,600	25,536	30,767
Combined	**31,188,514**	**32,727,342**	**34,316,952**	**38,672,568**

Risk Adjusted Unit Pricing (USD per m^3)	1 year	3 year	5 year	10 year
Quality Risk Premium	31.17	29.73	31.17	35.13
Water Bill Unit Price	0.02	0.03	0.02	0.03
Combined Risk Adjusted Price	**31.19**	**32.73**	**34.32**	**38.67**

Revenue Risk

Revenue Risk Likelihood Score:
HIGH

Revenue at risk compares the estimated amount of water a business requires to generate revenue (m^3 per USD of revenue) to the business' share of water available in the water basin if water were allocated among water users based on economic activity (contribution to basin-level GDP). If more water is required than the basin share of water allocated, then a proportion of the business' revenue is potentially at risk.



USD per year	1 year	3 year	5 year	10 year
Revenue At Risk (USD per USD)	1.00	1.00	1.00	1.00

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7.5. Costs of water risks for the Company (in numbers)

Table 13. Cost of water related risks calculation based on the Company´s available figures (yellow – actually paid but no data, orange – could be paid)

Risks	No actions against risk			Mitigate risks			Avoid risks		
		One time, in .000 €	Annually, in .000 €		One time, in .000 €	Annually, in .000 €		One time, in .000 €	Annually, in .000 €
Physical risks									
Too much water									
High groundwater table	Flooded fields restoration			Flooded fields restoration			Joint drainage maintenance		
Soil degradation	Less yields			Less yields			Groundwater level sensors		
Too little water									
Shortages in water supply from Chavimochic	Decreasing water demand by planting less areas, losses in profit			Pumping ground water for irrigation			Subsurface irrigation	900	
				Pre-treating water from Virú and Moche rivers			Hygroscopic moisturizers application		540
				Constructing reservoirs			Water costs savings Op.1 -10%		
							Water costs savings Op. 2 -30%		
							Water costs savings Op. 3 -40%		
Water pollution									
Water pollution	Discharge non-treated effluent in Virú or Moche rivers			Discharge to private/municipal wastewater			WWTP construction	2,500	

Risks	No actions against risk			Mitigate risks			Avoid risks		
		One time, in .000 €	Annually, in .000 €		One time, in .000 €	Annually, in .000 €		One time, in .000 €	Annually, in .000 €
				Pre-treatment and dispose			WWTP maintenance		1,000
Extreme water events (El Nino damages)									
Fields	Avocado and asparagus fields damage 250 ha	5,100		Insurance against floods for infrastructure	- 3,500		Joint PES program in highlands, to plant forest for water capturing during flood seasons		
Irrigation infrastructure	Irrigation systems for 5 ha								
Yields	Losses in sales	6,800		Business diversification					
Contractor´s losses (higher prices)	Peppers from farmers	1,700							
Transportation delays	Broken Moche bridge			Joint bridge reconstruction			Joint construction alternative transport delivery connection		
Plants, Storage	Flooded processing plant and store house			Protect buildings with sandbags walls					
Transportation infrastructure inside the Company									
TOTAL		€ 13,600			-€ 3,500			€ 3,400	€ 1,540

Risks	No actions against risk			Mitigate risks			Avoid risks		
		One time, in .000 €	Annually, in .000 €		One time, in .000 €	Annually, in .000 €		One time, in .000 €	Annually, in .000 €
Regulation risks									
Poor national/local water management	Difficulties in obtaining water permits						Strong stakeholder's engagement platform		
Industrial effluent exuding national standards	Fine from ANA								
Reputational risks									
Community concerns about used fertilisers / pesticides	Community protests			Fine / social payments			IPM practice		
	Sales decrease			Sales decrease					
Community concerns about water management	Community protests			Sales decrease			Sustainability reporting		
El Nino damage	Sick workers			Supply drinking water to community					
	Absence at work / reconstructing houses			Supply building materials					

7.6. Costs of water risks for the Company (colour-ranking by expenses)

Table 14. Estimated rating of costs of water related risks calculation (in EUR, 000): < 500 - Yellow; 500 – 1,000 - Orange; >1,000 – Red

Risks	No actions against risk			Mitigate risks			Avoid risks			
		One time	Annually		One time	Annually		One time	Annually	Additional Benefits
Physical risks										
Too much water										
High groundwater table	Flooded fields restoration			Flooded fields restoration			Joint drainage maintenance			More productive soil, higher yields, sustainable groundwater management etc. (see page 65)
Soil degradation	Less yields			Less yields			Groundwater level sensors			
Too little water										
Shortages in water supply from the Chavimochic	Decreasing water demand by planting less areas			Pumping ground water for irrigation			Subsurface irrigation			Direct fertilizers application in root-zone, higher productivity of crops, higher yield, less water consumption, less groundwater pollution, less impact on groundwater level etc. (see pages 65 - 66)
				Pre-treating water from Virú and Moche rivers			Hygroscopic moisturizers application			
				Constructing reservoirs			Water costs savings Op.1 -10%			
							Water costs savings Op. 2 -30%			
							Water costs savings Op. 3 -40%			
Water pollution										
Water pollution	Discharge non-treated effluent in Virú or Moche rivers			Discharge to private/municipal wastewater			WWTP construction			Additional water for irrigation. confidence for sufficient quality of discharge effluents etc. (see page 67)

Risks	No actions against risk			Mitigate risks			Avoid risks			
		One time	Annually		One time	Annually		One time	Annually	Additional Benefits
				Pre-treatment and dispose			WWTP maintenance			
Extreme water events (El Nino damages)										
Fields	Avocado and asparagus fields damage 250 ha			Insurance against floods for infrastructure			Joint PES program in highlands, to plant forest for water capturing during flood seasons			Less floods, less mudslides, less field and infrastructure damages during El Nino years etc. (see page 66)
Irrigation infrastructure	Irrigation systems for 5 ha									
Yields	Losses in sales			Business diversification						
Contractor´s losses (higher prices)	Peppers from farmers									
Transportation delays	Broken Moche bridge			Joint bridge reconstruction			Joint construction alternative transport delivery connection			Ensure transportation alternatives, no supply product delivery delays, no export products delay etc. (see page 66)
Plants, Storage	Flooded processing plant and store house			Protect buildings with sandbags walls						
Transportation infrastructure inside the Company										
Regulation risks										
Poor national/local water management	Difficulties in obtaining water permits						Strong stakeholder's engagement platform			Confidence in stable future (regarding water policies), stronger voice on local /

Risks	No actions against risk			Mitigate risks			Avoid risks			
		One time	Annually		One time	Annually		One time	Annually	Additional Benefits
										national water governance arena etc. (see page 67)
Industrial effluent exuding national standards	Fine from ANA									
Reputational risks										
Community concerns about used fertilisers / pesticides	Community protests			Fine / social payments			IPM practice			Community support, saved biodiversity, international consumers support, opened doors for international certification etc. (see page 68)
	Sales decrease			Sales decrease						
Community concerns about water management	Community protests			Sales decrease			Sustainability reporting			Community support, international consumers support etc. (see page 68)
El Nino damage	Sick workers			Supply drinking water to community						
	Absence at work / reconstructing houses			Supply building materials						

Costs rating:

< EUR 500,000.00

EUR 500,000.00 - 1,000,000.00

> EUR 1,000,000.00

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Declaration in lieu of oath

By

Anna Kalashnyk

This is to confirm my Master's Thesis was independently composed/authored by myself, using solely the referred sources and support.

I additionally assert that this Thesis has not been part of another examination process.

Place and Date | Signature